BSR/ASHRAE/USGBC/IESNA Standard
189.1P

Public Review
Draft

ASHRAE® Standard

Proposed Standard 189.1P, Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings

Second Public Review (February 2008)

(Complete Draft for Full Review)

This draft has been recommended for public review by the responsible project committee. To submit a comment on this proposed addendum, use the comment form and instructions provided with this draft. The draft is subject to modification until it is approved for publication by the ASHRAE Board of Directors and ANSI. Until this time, the current edition of the standard remains in effect. The current edition of any standard may be purchased from the ASHRAE Bookstore @ http://www/ashrae.org or by calling 404-

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(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

FOREWORD TO THE SECOND PUBLIC REVIEW

This foreword to the Second Public Review contains a discussion of changes made and not made after consideration of the comments received on the First Public Review Draft. Please note that, while there were numerous comments and there are numerous changes, this summary is only able to address some of the key issues. See the document for specific modifications.

OVERVIEW OF COMMENTS

The First Public Review in mid-2007 generated some 900 public comments scattered across most of the document. The largest number of comments addressed whether the proposed language in various sections was normative as required for a standard. The energy chapter received the most comments, followed by the definitions chapter. Approximately 10% of the comments were submitted by one commenter. The top four commenters were responsible for 25% of the comments. (Two of the top four commenters are affiliated with a code organization and most of their comments addressed format and phrasing as opposed to technical content.) Twenty-six commenters submitted 10 or more comments. These roughly two dozen commenters submitted approximately 60% of the total number of comments.

GENERAL ISSUES AND RESPONSES

There were some comments that, while in different sections, raised a common theme. A few of these issues are addressed below.

Documents must be in normative language to qualify to be referenced:

Standard 189.1 is a standard. It is not a design guide. Consequently, the documents that are referenced by Standard 189.1 must be written in normative language. There were a number of requests that Standard 189.1 be revised to reference guidelines or guides. For example, several ASHRAE members recommended that sections in Standard 189.1 that address building commissioning (10.3.1) or building acceptance testing (10.3.2), be revised to simply reference the ASHRAE Guidelines for Commissioning. However, these documents are not normative so they can not be referenced. So, for now, the text in Standard 189.1 has been revised for consistency with the terminology in those guidelines. Should these guidelines be converted to standards, they could be considered for future versions of Standard 189.1. Indeed, SSPC 90.1 has begun the process to convert their Informative Appendix G of Standard 90.1 into normative language to make it eligible to be referenced in future versions of Standard 189.1.

Requests to modify standards that are referenced in Standard 189.1 need to be directed to the group responsible for that standard:

Some commenters requested that Standard 189.1 be modified to address what they felt were shortcomings in standards that are referenced within Standard 189.1. However, Standard 189.1 is not a vehicle to “fix” any perceived problems in these standards. Commenters should address their comments to the appropriate committee or organization to pursue such modifications. For example, Standard 189.1 uses Standard 62.1 (Ventilation for Acceptable Indoor Air Quality) and Standard 90.1 (Energy Standard for Buildings Except Low-Rise Residential Buildings) as base documents and then builds on those documents. Some commenters asked for changes in those base documents. One commenter requested that the requirements for insulation R-values in Standard 189.1 be expressed in a different manner than that used in Standard 90.1. This comment is more appropriately submitted as a Continuous Maintenance Proposal (CMP) to SSPC 90.1. Comparable comments on Standard 62.1 are more appropriately submitted as CMPs to SSPC 62.1.

Environmental assessment:

There is a broad interest in high-performance green buildings. Key organizations are on record supporting major steps forward. Standard 189.1 seeks to incorporate criteria that will support high-performance, green building initiatives by national groups. While some rough assessments were made of the improvements in water-efficiency and energy-efficiency, there has been no overall environmental assessment of the criteria in Standard 189.1. Professional judgment has been used to set the criteria.

Economic assessment:

The charge to the Project Committee for Standard 189.1 was to develop a standard for high-performance, green buildings. The Project considered a variety of factors when using their professional judgment to establish minimum criteria. There has been no overall economic assessment of the criteria in Standard 189.1. Notwithstanding this, Standard 189.1 draws from experiences with other documents and other programs. There may have been some analysis done for those documents and programs. For example, some of the energy-efficiency criteria are drawn from ASHRAE’s Advanced Energy Design Guides (AEDG) and the New Building Institute’s (NBI) Core Performance Guide. As such, these criteria would implicitly include any economic assumptions made in the development of those documents.

Appropriateness of developing the standard:

Several comments advocated that the development of the standard be put on hold, converted to a guideline, or terminated. The reasons given were lack of representation on the committee, lack of cost benefit analysis, and general unsuitability. ASHRAE, USGBC, and IESNA have an agreement to jointly develop a standard for high-performance green buildings. Within these three groups, there is the expertise to develop such a standard and many of the individuals on the Project Committee have extensive previous work and experience in fields beyond their current employment. The development justification has gone through all of the required steps and been approved by the sponsoring organizations. The Project Committee was given a purpose and scope and charged to develop a standard with that purpose and scope. The Project Committee has followed ASHRAE and ANSI procedures to develop a standard in response to the charge given to it.

BROAD CHANGES

Some changes were made that affect multiple chapters. They are summarized here.

All references to informative material were deleted from the normative portions of the document. For example, cross-references to material in informative appendices were deleted. This was done to follow standards-writing protocol.

Submittal requirements (x.6) were deleted from all sections, as well as corresponding appendices. Such material was deemed more appropriate for a Users Manual.

Numbering was switched for the chapters on IEQ – Indoor Environmental Quality (now Chapter 8) and the Building's Impact on the Atmosphere, Materials and Resources (now Chapter 9).

CHAPTER 1: PURPOSE

In response to comments, the purpose was revised to clarify that it specifically includes all aspects of "design" from siting, to building design, to construction, through to plans for operation of the facility.

Some commenters misinterpreted the phrase on balance as calling for balance assessments within each of the subcategories listed, such as a balance of the resource efficiency for every criterion in the standard. The intent of the language is for a broad balance across all the factors listed.

CHAPTER 2: SCOPE

Section 2.1. The application of the standard was revised for consistency with Standard 90.1, applying to new buildings, new portions of buildings, and new systems in existing buildings. The reference for major renovations was deleted. The definition of a “building project” was moved to Chapter 3.

Section 2.2. The second exemption has been clarified to indicate that the exemption is for buildings that use no electricity and no fossil fuel and, in response to comments, no water. The first exemption was retained without modifications for consistency with Standard 90.1.

CHAPTER 3: DEFINITIONS, ABBREVIATIONS AND ACRONYMNS

More than 15 new definitions have been added, 13 definitions have been modified, and 10 definitions have been deleted. The impact of key definition changes is discussed in the context of the chapter where they are used.

Cross-references to definitions in other base documents cited (such as Standards 62.1 and 90.1) have been retained, rather than having the text be repeated or made more generic, so as to maintain ongoing consistency with those documents.

CHAPTER 4: ADMINISTRATION AND ENFORCEMENT

Discussion of integrated design moved entirely to Appendix G, since it was informative. (See Informative Appendix G for discussion of changes.)

CHAPTER 5: SITE SUSTAINABILITY

Section 5.3.1 Site Selection. Most changes were minor. While some commenters suggested deletion of this section, site selection is a crucial aspect of high performance green building and needs to be included. Some potential users, such as developers, corporations, and universities, can incorporate these criteria as a matter of policy into their building programs. In terms of potential adoption into a code, the local jurisdiction will likely assess possible differences between Standard 189.1 and its own Zoning Codes and Land Use laws. (Similarly, a local jurisdiction would likely compare its own Energy Code with the energy criteria in Chapter 7 of Standard 189.1.) If there are inconsistencies or conflicts, the local jurisdiction would need to decide where to make modifications.

For allowable sites, in response to requests for clarification, the phrase related to bus lines was replace by the term “adequate transit service” and a definition was added. Definitions for “fish and wildlife habitat conservation area” and “forest lands” were modified to ease implementation.

For prohibited development activity (rather than prohibited sites), the buffer areas within which no development could occur adjacent to fish and wildlife habitat conservation areas and wetlands have been decreased because the initial buffers were arguably larger than necessary for some situations and the proposed new changes are generally acceptable as adequate. It is challenge to place a one-size-fits-all buffer requirement for these critical areas because each area is unique. The numbers proposed are as reasonable as can be while taking this complexity into consideration.

Section 5.3.2 (formerly 5.3.3) Mitigation of Heat Island Effect. For site hardscape, a clarification was made that the time period for plantings to provide shading is within five years after the issuance of the final certificate of occupancy, and a default SRI for new concrete was moved up from the submittal section. For walls, the provision for shading of air conditioning condenser units and of south walls was removed (retained for lower portions of east and west walls). For roofs, the exemption from SRI requirements for cold climates was expanded to include climate zone 6, and the annual energy analysis exception was clarified to require at least 2% energy and CO2 savings. The methodology for determining Solar Reflective Index (SRI) was moved to its own subsection.

Section 5.3.3 (formerly 5.3.4) Reduction of Light Pollution. The luminaire cutoff requirements have been deleted due to the elimination of the luminaire classifications by IESNA as well as agreement that the other requirements in this section provide sufficient limits. For outdoor lighting trespass limits, the illuminance restrictions beyond the site boundary have been eliminated due to the difficulty in applying this requirement to sites where obstructions, such as other structures, preclude verification. An exception was added to allow the boundary in higher ambient zones to be defined at the curb line recognizing that restrictions of light trespass across a public right-of-way, such as a side walk, unnecessarily burdened compliance. The definitions of lighting zones in the footnote to the table were revised to clarify the intent.

Section 5.4.1 (formerly 5.3.2) Site Development. Rather than being a mandatory provision, there is now a prescriptive option (5.4.1) and a performance option (5.5.1) related to site development to allow an opportunity for creative stormwater management. The prescriptive option in this section is generally the same as the previous mandatory provision. An exception has been added for building projects on a brownfield site in light of the problematic issues related to infiltration on such a site. The criteria for greenfield sites remain unchanged as they were felt to be reasonable and effective requirements for site development on such sites. Note, that there is now a performance option for those who prefer an alternative to these criteria.

Section 5.5.1 (new) Site Development. This section is completely new and was added for the purpose of allowing project designers and developers to have some creativity in stormwater management and control techniques aside from the less comprehensive pervious area approach.

CHAPTER 6: WATER USE EFFICIENCY

The overall goals were to achieve a minimum of 20 percent reduction in indoor potable water use over the Energy Policy Act of 1992 fixture performance requirements, to improve water use efficiency in other commonly-found water-using equipment in nonresidential facilities, and to achieve a minimum of 50 percent reduction in outdoor potable water use over that consumed by conventional means. Rough calculations based on the water efficiency measures in Chapter 6 indicated indoor water savings of 35% for an office building and 26% for a multifamily building.

Section 6.3.2 Building Water Use Reduction. For plumbing fixtures and fittings, the requirements addressing multiple showerheads in a stall have been revised for clarity. For appliances, the criteria have been revised for greater consistency with the rating standards. For HVAC systems and equipment, a requirement has been added for condensate recovery from air conditioning units with a capacity greater than 19kW

(65,000 Btuh), minor modification made to the drift reduction criteria for cooling towers, and clarification made that the prohibition on once-through cooling applies to the use of potable water. For roofs, clarification was made that the prohibition on spraying applies to thermal conditioning purposes or irrigation of vegetated roofs.

Section 6.3.3 Water Metering. Initial statement on rationale was deleted as unnecessary. The sub-metering categories and thresholds in Table 6.3.3-2 were clarified.

Section 6.4.1 Site Water Use Reduction. The exception to allow the use of potable water for a “landscape establishment period” was clarified through the addition of a definition.

Section 6.4.2 Building Water Use Reduction. For cooling towers, a second option for the cycles-of-concentration provision was added in recognition of local differences in water hardness. The exception for total dissolved solids in blowdown was revised slightly.

For commercial food service operations, the requirements for dishwashers and air-cooled ice machines were made consistent with the EnergyStar criteria. Water-cooled ice machines were deleted. The requirement for hands-free faucet controllers in the kitchen area was made more explicit. A limit was added for water use in combination ovens.

Section 6.4.3 Special Water Features. For ornamental fountains, a requirement was added for a leak-detection device. An exception was added to allow the use of potable water for start-up and make-up where alternate on-site sources of water or municipally-reclaimed water are not available nearby.

Section 6.5.1 Site Water Use Reduction. The limitations on the use of alternate sources of water for irrigation were dropped.

CHAPTER 7: ENERGY EFFICIENCY

The overall goal was to achieve a minimum of 30 percent reduction in energy consumption over that in ASHRAE/IESNA Standard 90.1-2007. Calculations were to include the entire energy consumption of the project and be done in accordance with Appendix G of Standard 90.1.

The U.S. Department of Energy (USDOE) , through the National Renewable Energy Laboratory (NREL), has made a PRELIMINARY estimate based on the FIRST Public Review Draft of Standard 189.1P. This analysis included the energy efficiency measures in Chapter 7, as well as other measures in Chapter 5 (e.g. increased outdoor air quantities) and Chapter 8 (e.g. minimum effective aperture for sidelighting) that would increase energy consumption and therefore reduce energy savings. The methodology used 15 buildings representing the typical range of commercial buildings from offices, retail, schools, to warehouses in 16 different locations representing each of the major climate zones including variations for humidity. They found that applying the minimum set of prescriptive recommendations in Standard 189.1P led to site energy savings ranging from 10% to 41% over Standard 90.1-2007, including plug and process loads and all other energy consumption for the building. The weighted average across all building types in all climates was 24.9%.

The caveats: There are measures within Chapter 7 of Standard 189.1P that were not included in the modeling. Consequently, there are likely to be additional energy savings beyond that estimated. In addition, USDOE is currently working on an update to the analysis to more accurately reflect the changes in the SECOND Public Review Draft and perhaps to include energy efficiency measures that were omitted from the earlier analysis.

Another goal was to provide leadership in renewable power generation on-site. High-performance, green buildings would lead the way by avoiding a total reliance on conventional energy sources. Building projects would produce a minimum percentage of their peak electrical load through on-site generation, such as by photovoltaic panels.

Section 7.3.2 (formerly 7.3.3) On-site Renewable Energy Power Systems. The definition of the building service has been modified to clarify that the 1% requirement is meant to be applied against the building’s electrical service overcurrent protection device rating as opposed to the building’s electrical service size and the intent is to require the larger amount. The second exception has been simplified to allow any combination of energy cost savings and CO_2e savings achieving a minimum of 10% total, demonstrated using the performance option in Section 7.5.

Section 7.3.3 Energy Metering. This section has been revised to parallel that for water metering (6.3.3). The sub-metering categories and thresholds in Table 7.3.3-2 were clarified, and errors were corrected in SI conversions. The requirement for meters to be “utility-grade” was deleted.

Section 7.4.2 Building Envelope. A new table for single rafter roofs was added as Table A-9 in Appendix A.

The vestibule requirements were retained because of the cold winters in climate zone 4.

The requirement limiting solar gains on east and west facades was retained because of its potential to save energy, although it was also clarified. Where buildings are designed to have only west or east facing glazing and cannot otherwise meet these criteria, the performance path in Section 7.5 can be used. Material and design choices are available so that the requirements of this section do not conflict with the daylighting requirements in Section 8.4.1 for office spaces and classrooms.

Comments were received to delete the exception for a continuous air barrier for some climate zones and building types. This is the same exception as in the proposed addendum z to Standard 90.1-2004 on continuous air barriers, developed under the ASHRAE consensus process, so the exception was retained.

(Also see the Appendix A discussion below regarding changes to the Prescriptive Building Envelope Tables.)

Section 7.4.3 Heating, Ventilating, and Air Conditioning. Criteria were added to allow elimination of economizer where higher-efficiency equipment is installed. These criteria vary by climate due to the differences in economizer benefits.

For economizers, two-stage thermostats were mandated. Exceptions were added for air economizer systems with higher equipment efficiency, and for smaller geothermal/water source heat pumps when water loops have the capability to be reset to a lower temperature.

The thresholds for heat recovery were revised to be consistent with those being considered for Standard 90.1.

The table of maximum flow rates for piping system design was revised, with rates being increased slightly. The flow rates for the pipe sizes were selected for the lowest combined energy and first cost for each pipe size. Flow limits to control noise and erosion are not included, these are design issues and are left to the judgment of the designer.

In response to several other ventilation-related comments, dedicated outside air systems were discussed extensively but no agreement was reached on how to specify such a requirement. The duct sealing requirements were retained.

(Also see the Appendix C discussion below regarding changes to the Prescriptive Equipment Efficiency Tables.)

Section 7.4.6 Lighting. The provisions for automatic controls for egress and security lighting were modified to be less restrictive with respect to the amount of lighting that can be continuously operated for the purposes of security or emergency lighting.

For automatic controls for lighting in daylight zones, two exceptions were added to address special conditions.

Section 7.4.7 Other Equipment. The requirements for many types of “other equipment” were moved here to be a prescriptive option, rather than a mandatory provision (formerly 7.3.2). Note that the requirement is that the products “comply with the equivalent criteria required to achieve the EnergyStar label”. The requirement has been set to match the technical criteria as these are widely known in the industry, but does not require commitments for marketing, etc. Thus, manufacturers are not required to participate in the EnergyStar program, nor are products required to have an EnergyStar label. Some minor revisions were made to bring the listing of product criteria up-to-date, including adding commercial ice machines and commercial dishwashers.

For commercial reach-in refrigerator/freezer display cases (formerly 7.3.2.2), in response to comments, the lighting criteria now specifies performance (maximum wattage), rather than requiring a specific technology (i.e. LED).

The requirement for wastewater heat recovery from commercial dishwashers was deleted.

Section 7.5.2 Annual Energy Cost. (See the Appendix D discussion below regarding changes to the Performance Option For Energy Efficiency.)

Section 7.5.3 Annual Carbon Dioxide Equivalent (CO2e). There were a number of comments asking for the source of the emission factors and why certain values were chosen. The CO2e emission factors in Table 7.5.3 are now updated for consistency with the June 2007 update to “Source Energy and Emission Factors for Energy Use in Buildings” by M. Deru and P. Torcellini (NREL/TP-550-38617, available for download from www.nrel.gov). This report was prepared by the National Renewable Energy Laboratory (NREL) for the U.S. Department of Energy. The original June 2006 version had previously been used for this data. The report contained multiple values for natural gas which were combined into one value for consistency of implementation. The report does not contain values for biomass, so no values were included. The emission factors listed in Table 7.5.3 have also been expressed on a consistent "mass of CO2 per kWh of energy" basis for all energy sources. The NREL report listed emission factors for on-site fuel combustion differently (mass of CO2 per mass or volume of fuel consumed) than for electricity, but for simplicity all emission factors have been translated into one consistent format.

Standard 189.1 specifies the values from the NREL report for the energy used to generate electricity at the national level, rather than the regional-interconnection level or the state level, for several reasons. First, U.S. federal laws now enable electricity to be wheeled anywhere in the United States, so the source of the electricity is not limited to a region or state. Second, some utilities (e.g. Seattle City Light) use hydropower to produce most of their electricity and then purchase offsets for the rest, thereby having net-zero carbon emissions, and it did not make sense to declare all buildings served by such utilities as having net-zero emissions. There was no intent or effort to align carbon values with those used for carbon trading schemes.

It is important to include current estimates of emissions impacts in Standard 189.1 now so that designers and policymakers can begin to assess these impacts. This field is likely to be the source for more ideas for future versions of Standard 189.1

Section 7.5.4 (new) Load Factor/Peak Electric Demand. This section in the performance option is meant to parallel the one in the prescriptive option (7.4.5) and is intended to improve building load factors.

CHAPTER 8 (formerly Chapter 9): INDOOR ENVIRONMENTAL QUALITY (IEQ)

Section 8.3.1 (formerly 9.3.1) Minimum Indoor Air Quality. A number of changes have been made to this section in response to comments, and for consistency with, or to avoid conflicts, with ASHRAE's Advanced IAQ Design Guide, now under development.

Several key changes were made in response to concerns over the potential negative impacts associated with outdoor airflow rates that exceed the Standard 62.1 Ventilation Rate Procedure (VRP). First, exceptions have been added for humid climates (climate zones 1A and 2A) and for areas with problematic outdoor air quality (i.e. those areas in “non-attainment” with the U.S. National Ambient Air Quality Standards). Second, additional filtration requirements (MERV 8 for some areas and MERV 13 for non-attainment areas) have also been included.

The U.S. non-attainment areas can be viewed at the U.S. EPA website at http://www.epa.gov/air/data/nonat.html?us~USA~United+States

There are roughly 3000 counties in the United States. As of December 2007: there are approximately 350 counties in non-attainment for ozone (O_3, many of the major metropolitan areas), roughly 200 counties for particulates (significant overlap with ozone), only 7 counties for sulfur dioxide (SO_2), only 5 counties for carbon monoxide (CO), only 2 counties for lead, and none for nitrogen dioxide (NO_2). The net effect of adding the exception for non-attainment areas is that this will exempt a significant portion of the populated areas in the United States.

Exceptions for humid climates (climate zones 1A and 2A) and cold climates (climate zones 6, 7, and 8) address concerns over the energy impacts of increased ventilation rates in the extreme climate zones.

Although outdoor airflow rates in all cases may not go below the rates prescribed by the Standard 62.1 VRP, another exception allows the Standard 62.1 IAQ Procedure to be used for design of spaces that are required to have increased ventilation (previously this was not allowed). In this case, outdoor airflow rates may be reduced to the Standard 62.1 VRP levels if the designer can demonstrate that contaminant concentrations are lower than those with the increased ventilation rates.

The increased ventilation requirement remains for all classrooms and office spaces that are not exempted, due to the potential benefit of such increased ventilation (see, for example, Taylor, S. 2005. “LEED® and Standard 62.1.” ASHRAE Journal 47(9):S4-S8.)

The term “design minimum outdoor airflow rate” has been introduced to aid in coordination with the reheat requirements in Section 7.4.3.

Section 8.3.3 (formerly 9.3.3) Outdoor Air Delivery Monitoring. In response to comments, there have been considerable overall wording changes to clarify the intent. An exception concerning the outdoor air flow not required to be larger than specified in Standard 62.1 was removed as it was considered to be redundant.

Section 8.3.6 Acoustical Control. For exterior sound, Outdoor-Indoor Transmission Class (OITC) was added as a criterion. Also, for noise levels at the property line, the term “yearly average day-night average sound levels” (a term of art in the industry) is now used instead of “regularly exceeding”, and added to the definitions chapter. This change was based on ANSI S 12.60-2002, Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools. The term “interstate highways” was changed to “expressways” and a definition was added.

For interior sound, additional criteria were added for assemblies separating spaces based on ANSI S 12.60-2002, a guideline. No criteria were added for acoustical control of sound within a space due to the perceived complexity and lack of a standard. Acoustical control of sound within a space is covered in ASHRAE Handbook – HVAC Applications, Chapter 47, “Sound and Vibration Control,” but this is not a standard.

The methodology for determining Sound Transmission Class (STC) was moved to its own subsection, and the methodology for determining Outdoor-Indoor Transmission Class (OITC) was added.

Section 8.4.1 (formerly 9.4.1) Daylighting by Sidelighting. The effective aperture requirement has not changed. Existing research shows that increased effective aperture, to a point, decreases energy consumption (Sullivan, R. et al. 1992. A Method of Optimizing Solar Control and Daylighting Performance in Commercial Office Buildings. ASHRAE/DOE/BTECC Conference Proceedings, "Thermal Performance of the Exterior Envelopes of Buildings V, "December 7-10, 1992, Clearwater Beach, FL.)

Section 8.4.2 (formerly 9.4.2) Low Emitting Materials. Minor clarifications were made. Informative notes were removed per Standards protocol noted above. (Informative references are still retained in Informative Appendix F.)

A wholesale change of reference to California Section 01350 was not made because it is more
appropriate to the performance option where it is currently located. Subsections within 8.4.2 that
do refer to California Section 01350 also include a labeling requirement which is appropriate for
the prescriptive nature of the section.

For floor-covering materials, the reference to SCS EC10 was updated to its current version of SCS-EC10.2-2007. A generic third party certifier would be preferred but was not found. References to publicly available documents were left (as opposed to inclusion of the entire document) for conservation of space.

Plywood has been added as a specific product included in the section with composite wood and agrifiber products, as it does not exactly belong to either category. The exception was left as before due to discussions suggesting that the requirement for “no added urea-formaldehyde resins” would not limit structural products. A reference to the CARB ATCM for composite wood was not included here because it is not a completed document.

Batt insulation materials have not been added to 9.4.2 (prescriptive option) but have been retained in 9.5.2 (the performance option).

Section 8.5.2 (formerly 9.5.2) Low Emitting Materials. Minor clarifications were made. Informative notes were removed per Standards protocol noted above. The reference to “CDHS California Section 01350” was updated to be CA/DHS/EHLB/R-174 which is the superseding version of Section 01350. Acoustical ceiling tiles were added to the list of materials to be tested. Existing testing requirements using flow rates described in California Section 01350 were kept to minimize confusion and because of the existing connection with ASHRAE Standard 62.2. Although desirable, the addition of text requiring an “approved test laboratory” for California Section 01350 was not included due to the lack of definition for approved laboratories.

CHAPTER 9 (formerly Chapter 8): BUILDING’S IMPACT ON ATMOSPHERE, MATERIALS, AND RESOURCES

Section 9.3.1 (formerly 8.3.1) Construction Waste Management. The criteria for construction waste management were retained but the language was clarified. Manufacturer take-back programs are considered a means of acceptable diversion and were not specifically listed. Comments were received, but not incorporated, on limiting the amount of construction waste to a specific mass per unit of floor area. While this is a desirable goal and is included in some guidelines as a goal, the specific values that were suggested from guidelines have not been tested as minimum criteria in normative language to see whether they are realistic and achievable. Also, demolition waste is often intermingled with construction waste, obscuring the ability to measure construction waste separately. Comments were also received, but not incorporated, requesting that the reduction in material due to the optimization of design or material supply techniques be included as diverted waste. This may be appropriate for guidelines but is too challenging to quantify and verify within an enforceable code standard.

Section 9.3.2 (formerly 8.3.2) Wood Products. In response to comments, clarification was made that the requirements do not apply to recovered or reused wood. In response to comments, minor clarifications were made to the language allowing endangered wood species if their trade conforms with the requirements of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Section 9.3.3 (formerly 8.3.3) Refrigerants. In response to comments, minor changes were made to remove the unnecessary portion of the text providing reasoning for the requirement. Other comments requesting deletion of the section or substitution of alternate language were not incorporated as they did not offer a balance of the environmental issues. One comment requested inclusion of peer reviewed references substantiating the basis of the requirement. The criteria was retained as Standard 189.1 is based on professional judgment, and peer reviewed substantiation is not a requirement.

Section 9.3.4 (formerly 8.3.4) Storage and Collection of Recyclables and Discarded Goods. This section requires an area for storage of non-hazardous materials for recycling. Areas for collecting ink cartridges, toner cartridges, batteries, and electronic equipment were not added due to the challenge of appropriately recycling these items and their potential to be hazardous materials.

Section 9.4.1 (formerly 8.4.1) Reduced Impact Materials. A number of revisions were made in response to comments and to incorporate text that was previously included in the submittal section.

A change was made to exclude components of mechanical, electrical, and plumbing systems from the calculations due to the difficulty of obtaining the necessary information. The allowance to use a value of 45% of the total construction cost in lieu of the actual total cost of materials was moved up from the submittal section.

For recycled content, the allowance to use the annual average industry values for the recycled content of steel products manufactured in basic oxygen furnaces and electric arc furnaces as the recycled content of the steel was moved up from the submittal section. In response to comments, supplementary cementitious materials were identified (e.g. fly ash, slag cement, or silica fume). The recycled content of the supplementary cementitious materials in concrete was retained as the recycled content of the concrete due to the fact that these materials replace Portland cement which contributes most of the embodied energy and CO_2 in concrete. A clarification was added to ensure that the amount of cementitious materials is not increased beyond standard practice (i.e. compared to a baseline 28-day strength mix design using only Portland cement and meeting the same specified performance requirements).

For regionally extracted/harvested/recovered and manufactured materials, the requirement has been reformatted. The previous first option, specifying an 800 km (500 mi) radius of the project site, has now been established as the baseline. The other previous options, allowing a 2400 km (1500 mi) radius for goods shipped by rail or water, or allowing a combination of the two, have now been combined into an exception. That exception contains an equation to clarify how the weighting is to be calculated.

For bio-based materials, a clarification was added that wood building components from a vendor are allowed to comply when the annual average amount of certified wood products purchased by the vendor is 70% or greater of their total annual wood products purchased. Standard 189.1 contains an open-ended list (“include but are not limited to”) of wood building components that are allowed to comply. Requests were made to add products to this list, but it would never be possible to have a complete listing, and the longer the list becomes the more likely the list would be seen as a complete list excluding other products rather than being open-ended.

Informative notes were removed per Standards protocol noted above. (Informative references are still retained in Informative Appendix F.)

Section 9.5.1 (formerly 8.5.1) Life Cycle Assessment. This section describes the life cycle assessment (LCA) performance option. The intent, to perform an LCA for a whole building for its life cycle, has been retained. Some modifications were made for clarification and some corrections were made. Both building alternatives must conform to the owner’s project requirements.

For the LCA performance metric, solid waste has been taken out of the list of impact categories because most models calculate solid waste as the weight of the building and assume it is sent to a landfill with no recycling or reuse.

For the calculation procedure, clarifications have been made. Existing simulation tools are available that comply with this section and have databases for North American materials. Note that SimaPro has impact assessment methods that comply, including Ecoindiator-99 and Impact 2002+. Other impact assessment methods that comply include Traci and Smart, as long as the full building life cycle is considered. The existing version of BEES does not comply with Standard 189.1 because it does not cover the full life (but it does have the full range of impacts). It is cradle to gate with the gate being the end of construction. ATHENA Impact Estimator for Buildings does not appear to cover the full range of impacts (but it can do full life).

Reporting has been added as a separate subsection.

CHAPTER 10: CONSTRUCTION AND OPERATION PLANS

Standard 189.1 continues to include plans for construction and operation, as specifically now cited in the purpose at the very beginning of the standard. Some comments recommended omitting Chapter 10 in its entirety from Standard 189.1 primarily because they believe it is unenforceable, in particular those portions calling for specific actions that carry forward beyond construction into building operations, e.g., implementation of measurement and verification plans (10.3.3). Bear in mind that there are a wide range of potential users of Standard 189.1, from individual building owners to corporations and universities to municipalities to code agencies. From the beginning, Standard 189.1 has been intended to provide a standard for high performance green buildings. This requires consideration of downstream building operations and many potential users of Standard 189.1 are capable of doing that. For this reason, operation plans continue to be included in Chapter 10. Note that so as to enable enforcement of operation plans by the authority having jurisdiction, should they choose to do so, text has specifically been included in Chapter 10 regarding the maintaining of record documents of these activities by the building owner.

Section 10.3.1 Building Project Commissioning. A number of commenters recommended that the current text in Sections 10.3.1 and 10.3.2 be deleted and that Chapter 10 simply reference ASHRAE Guideline 0 and ASHRAE Guideline 1. As noted in the discussion of general issues in the beginning, these guidelines are not written in normative language so they cannot be referenced in a standard.

Concern was expressed by reviewers that the terminology and definitions and some process steps in Standard 189.1 did not match with those used in ASHRAE Guideline 0-

2005 and ASHRAE Guideline ASHRAE Guideline 1-2007, both of which deal with the commissioning process. While it can be argued that the industry has not, as a whole, come to normalize terminology and definitions, Standard 189.1 has been revised with the goal of greater consistency with these ASHRAE Guidelines.

For the systems to be commissioned, some commenters requested that Standard 189.1 list very specific systems or provide specific procedures for commissioning specific systems. Minor changes were made so that the text is broad enough to be inclusive of those specific systems requested. Including specific system commissioning procedures was not deemed to be necessary or appropriate for this document. Such recommendations could be brought to ASHRAE’s Technical Committees.

Informative notes were removed per Standards protocol noted above. (Informative references are still retained in Informative Appendix F.)

Section 10.3.2 Building Acceptance Testing. A number of commenters asked that this section be removed. Some believed this section was redundant with 10.3.1 requirements, apparently not understanding that Section 10.3.1 is applicable to buildings that exceed 500 m2 (5,000 ft2) of gross floor area, and Section 10.3.1 is applicable to smaller buildings with 500 m2 (5,000 ft2) or less gross floor area. Other commenters recognized the distinction, but still simply wanted to use Section 10.3.1 for all projects, regardless of size. The original rationale, which is still maintained in Standard 189.1, is that the requirements for in Section 10.3.1 are excessive for very small projects. The precedent is the procedure used today in California for smaller building acceptance testing found in the CEC Nonresidential Compliance Manual which is an informative reference listed in Informative Appendix F. Section 10.3.2 used the CEC Nonresidential Compliance Manual as a guide.

Section 10.3.3 Measurement and Verification Plan. Limited changes were made, except for indoor environmental quality. For energy efficiency, minor clarifications were made for the CBECS benchmarking compliance option and the energy simulation compliance option.

For indoor environmental quality, there have been considerable overall wording changes to clarify the intent in response to comments, and for consistency with, or to avoid conflicts, with ASHRAE’s Advanced IAQ Design Guide, now under development. A new term, “action level”, has been include that defines the level of CO2 concentration that the operator, owner or occupant should consider to be an elevated level and thus when to take action. A new table has been included in Appendix E where the action levels are listed. (Also see the Appendix E discussion below regarding changes to the Space Contaminant Concentration Action Levels.) The percentage level below design outdoor air flow that requires action has been changed to 15% (was 10%) for consistency with typical sensor accuracy. The text now allows any independent third party to be involved with investigating if a naturally ventilated space exceeds the CO2 action levels.

Section 10.3.5 Service Life Plan (formerly Durability Plan). The requirements remain essentially the same but the terminology was changed from “durability plan” to “service life plan” in response to comments. Compliance was simplified by removing the “failure category” and “effects of failure” as documentation requirements. Other changes were made for clarification.

Section 10.3.6 Transportation Management Plan (TMP). This section is completely revised. The previous version had a goal of a 15% reduction in single occupancy vehicle (SOV) trips to and from the building. In addition, parking space limits were established based on specific building types. Commenters raised significant issues about the procedures to determine the reduction, as well as with the parking space limits. Several comments were received suggesting the use of the “Best Workplaces for Commuters” criteria which provides flexibility for all types of buildings. In response, Standard 189.1 was revised to incorporate many of the features of the “Best Workplaces for Commuters” program.

The subsection focused on the building owner requires that the owner provide certain benefits to their own employees. They must offer one of five primary benefits, three supporting benefits if they have at least 20 employees, and a group of other benefits – one of which is a commitment to ensuring that within 18 months at least 14 percent of employees will not be driving alone to work.

The subsection focused on the building tenant requires that the owner provide the tenants with a copy of the owners plan for their own employees, and that the building owner not include parking fees in lease rates. This allows building tenants to pay only for the parking they truly need.

Section 10.3.8 Indoor Air Quality (IAQ) Construction Management Plan. The reference to “generally accepted engineering practice” was removed. The text related to an IAQ management plan was moved to the measurement and verification plan section (10.3.3). Informative notes were removed per Standards protocol noted above. (Informative references are still retained in Informative Appendix F.)

Section 10.3.9 Construction. For no-idling of construction vehicles, details were added to assure that vehicles that are allowed to idle during construction (meeting the excepted provisions) are stationed in vehicle staging areas, and that those staging areas are not affecting indoor air quality of the building or surrounding facilities.

For moisture control, the text has been changed to allow cleaning of materials that have evidence of biological growth due to the presence of moisture. Many guidelines for cleaning are available, but they are challenging to convert to normative language and not all use environmentally preferable cleaning supplies. Therefore, the method of cleaning was not specified. With regards to comments on landscaping sprinklers, additional requirements for landscape irrigation systems are contained in Chapter 6.

NORMATIVE APPENDIX A: PRESCRIPTIVE BUILDING ENVELOPE TABLES

Several commenters asked about the process used to develop the prescriptive building envelope criteria. Although there are some modifications and exceptions, the criteria for the opaque portion of the building envelope use the same format as Standard 90.1-2007 and were developed based on professional judgment as outlined below.

For nonresidential spaces, the building envelope criteria are based on the most stringent of the criteria in E-Benchmark 1.1 (now Core Performance as of July 2007) and the

Advanced Energy Design Guides (AEDG) for Small Office and the AEDG for Small Retail Buildings, provided that those criteria were more stringent than the requirements in Standard 90.1-2007. Where the criteria in Standard 90.1-2007 were equal or more stringent, the requirement was raised by an increment except in some cases in some milder climate zones.

For residential spaces, the building envelope criteria are the same as that for nonresidential spaces where the nonresidential and residential criteria are the same in Standard 90.1-2007. Where the residential criteria are more stringent in Standard 90.1-2007, then they have also been made more stringent here.

For semiheated spaces, the building envelope criteria also have increased stringency.

In response to comments, some limited modifications were made. Portions of Tables A-1 to A-5 were revised so that the metal building roof insulation R-value requirements for semi-heated spaces are at least as stringent as the metal building wall insulation R-value requirements for those same spaces. Portions of Tables A-2 and A-3 were revised so as to not increase the stringency of insulation R-value requirements for mass floors, such as over parking garages, based on technical comments received. (The values stay the same as Standard 90.1-2007. If there are concerns about the values in Standard 90.1-2007, that issue would need to be raised with SSPC 90.1.) Portions of Table A-8 were revised so that the wall insulation R-value requirements are not more stringent for wood-framing than for other frame wall types (assembly U-factors, however, will be lower for wood-framing). Some insulation R-value requirements are more stringent for wood-frame floors but this parallels Standard 90.1. In addition, typos were corrected in the footnotes and the footnotes were inserted in the correct cells in the tables.

In response to a comment, a new table for single-rafter roofs was added as Table A-9. Single-rafter roofs are a separate type of construction, distinct from attics, roofs with insulation entirely above deck, and metal buildings.

As noted in the general issues section above, one commenter requested that the requirements for insulation R-values in Standard 189.1 be expressed in a different manner than that used in Standard 90.1. As Standard 189.1 uses Standard 90.1 as a base document, this comment is more appropriately submitted as a Continuous Maintenance

Proposal (CMP) to SSPC 90.1.

NORMATIVE APPENDIX C: PRESCRIPTIVE EQUIPMENT EFFICIENCY REQUIREMENTS

For Table C-2 (Electrically Operated Unitary and Applied Heat Pumps – Minimum Efficiency Requirements), in response to comments, an error was corrected for the EER for air-cooled air conditioners in the cooling mode, the efficiencies were reduced by 0.2 EER to account for the additional losses of a 4-way valve and suction line accumulator as this is the practice that Standard 90.1 uses.

For Table C-3 (Water Chilling Packages – Minimum Efficiency Requirements), in response to comments, an error was corrected and IPLV efficiencies were added for double-effect absorption chillers.

For Table C-13 (Warm Air Furnace and Combustion Warm Air Furnaces/Air Conditioning Units, Warm Air Duct Furnaces and Unit Heaters), the outdoor application category of duct furnaces that had been inadvertently omitted was added, the placement of footnotes in the table was corrected, and new footnote h was added incorporating requirements from the Energy Policy Act of 2005 for intermittent ignition devices (IID) and either power venting or automatic flue dampers.

For Table C-14 (Gas and Oil Fired Boilers - Minimum Efficiency Requirements), in response to comments as well as changes in format for Standard 90.1, minimum efficiencies were generally reduced, also new footnote f was added indicating that systems with condensing boilers are to be designed with lower operating return hot water temperatures, i.e. <55 C (130 °F), and use hot water reset to take advantage of the higher efficiencies of condensing boilers.

For Table C-15 (Performance Requirements for Heat Rejection Equipment), in response to comments, the table has been revised to reflect new test procedures for closed circuit cooling towers, a complete set of performance requirements is now included, and clarification added that ratings are to be done at the 1.0% Design Evaporation WB temperatures listed in ASHRAE Standard 169.

For Table C-16 (Minimum Duct Insulation R-Value for Cooling and Heating Only Supply Ducts and Return Ducts), in response to comments, the insulation R-value requirements were increased for ducts in unconditioned space in some climate zones.

For Table C-17 (Minimum Duct Insulation R-Value for Combined Heating and Cooling Supply Ducts and Return Ducts), in response to comments, the insulation R-value requirements were increased for ducts in unconditioned space in some climate zones.

For Table C-18 (Minimum Pipe Insulation Thickness), the SI conversions for pipe insulation thicknesses were corrected, but the I-P requirements were not changed. One commenter suggested that insulation requirements should vary by pipe material type. As noted in the beginning, Standard 189.1 uses Standard 90.1 as a base. Recommendations for revisions to the format of criteria should be directed to SSPC 90.1.

For Table C-21 (Transformer Minimum Efficiencies), in response to comments, the criteria for transformers larger than 600 volts have been eliminated from the table, the other values have been modified to be consistent with recently updated federal requirements. Even though Table C-21 does not add requirements above federal requirements, this table has been provided for convenient reference.

Tables were deleted for air-cooled ice cube equipment (formerly Table C-22) and for water-cooled ice cube equipment (formerly Table C-23) as these are now covered in the EnergyStar program. This equipment is now addressed in Section 7.4.7.

NORMATIVE APPENDIX D: PERFORMANCE OPTION FOR ENERGY EFFICIENCY

Several commenters pointed out that changes that had been made to Appendix G to Standard 90.1 had not been incorporated into Appendix D in Standard 189.1. This was an inadvertent omission. Appendix D has been revised to incorporate these changes from Standard 90.1 Appendix G.

Informative notes were removed per Standards protocol noted above. (Informative references are still retained in Informative Appendix F.)

NORMATIVE APPENDIX E: SPACE CONTAMINANT CONCENTRATION ACTION LEVELS

This appendix has been completely revised to now provide an easy means for determining appropriate CO2 concentrations to use as the action level for outdoor air monitoring systems. The approach has been changed to a look-up table that is simpler (previously was equations), and also better suited for multi-zone systems.

The approach is based on the design outdoor ventilation rate per person in each zone. The design outdoor ventilation rate per person can be taken from the “Combined Outdoor Air Rate” in Standard 62.1, Table 6-1. The action levels listed in the new Appendix E have been rounded slightly upward to reflect the potential for sensor accuracy and temporary fluctuations or situations.

The table shows the calculated actual CO2 concentration difference above ambient based on two different metabolic activity levels, and the resulting corresponding action levels included in the proposed Standard.

INFORMATIVE APPENDIX G: INTEGRATED DESIGN

In response to comments, terminology has been revised and the process has been more clearly explained.

FOREWORD

This is the first edition of ASHRAE/USGBC/IESNA Standard 189.1. This is a standard for high-performance green buildings. It is not a rating system, though it could be incorporated as the baseline in a green building rating system. It is not a design guide. Because this is a standard, it references documents that are in normative language. (Consequently, guides and guidelines are not eligible for inclusion, even though they may contain useful strategies for designers.)

Standard 189.1 addresses site sustainability, water use efficiency, energy efficiency, indoor environmental quality (IEQ), and the building's impact on the atmosphere, materials and resources. These five key subject areas, as well as construction and operation, are each addressed in a separate chapter using the following format:

x.1 General: This subsection includes a statement of scope and addresses other broad issues.

x.2 Compliance Paths: This subsection indicates the compliance options for each section.

x.3 Mandatory Provisions: This subsection contains the criteria that must be complied with by all projects (i.e. the criteria that can not be traded off).

x.4 Prescriptive Option: This subsection contains additional criteria specified in a manner that provides a simple way to show compliance that involves little or no calculations.

x.5 Performance Option: This subsection contains an alternate way to show compliance that is typically based on equivalence to the Prescriptive Option.

This standard is meant to be used in conjunction with ASHRAE/IESNA Standard 90.1-2007, and ASHRAE Standards 62.1-2007 and 55-2004. Where a requirement is contained herein, this requirement supersedes the requirements in those standards. For all other criteria, the project is to comply with the requirements in those standards. (Note that Standard 189.1 is not intended to change the structure or contents of Standards 90.1 and 62.1 except as they apply to high-performance green buildings. Suggestions for Standards 90.1 and 62.1 should be submitted to the appropriate project committee using the ASHRAE continuous maintenance proposal (CMP) process.)

Following approval, Standard 189.1 is expected to be placed on continuous maintenance, permitting the standard to be updated through the publication of approved addenda to the standard. The standard is expected to be republished in its entirety every third year. All approved addenda and errata will be included in the new edition.

CONTENTS

ASHRAE/USGBC/IESNA Standard 189.1,

Standard for High-Performance Green Buildings
Except Low-Rise Residential Buildings

SECTION PAGE

1. PURPOSE

The purpose of this standard is to provide minimum requirements for the siting, design, construction, and plan for operation of high performance, green buildings to:

(a) balance environmental responsibility, resource efficiency, occupant comfort and well being, and community sensitivity, and

(b) support the goal of development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

2. SCOPE

2.1 This standard provides minimum criteria that:

(a) apply to the following elements of building projects:

1. new buildings and their systems.

2. new portions of buildings and their systems.

3. new systems and equipment in existing buildings.

(b) address site sustainability, water use efficiency, energy efficiency, indoor environmental quality (IEQ), and the building’s impact on the atmosphere, materials and resources.

2.2 The provisions of this standard do not apply to:

(a) single-family houses, multi-family structures of three stories or fewer above grade, manufactured houses (mobile homes) and manufactured houses (modular).

(b) buildings that use none of the following: electricity, fossil fuel, or water.

2.3 This standard shall not be used to circumvent any safety, health, or environmental requirements.

3. DEFINITIONS, ABBREVIATIONS, AND ACRONYMS

3.1 General

Certain terms, abbreviations, and acronyms are defined in this section for the purposes of this standard. These definitions are applicable to all sections of this standard.

Terms that are not defined herein, but that are defined in standards that are referenced herein (e.g. ASHRAE/IESNA Standard 90.1) shall have the meanings as defined in those standards.

Other terms that are not defined shall have their ordinarily accepted meanings within the context in which they are used. Ordinarily accepted meanings shall be based upon American standard English language usage as documented in an unabridged dictionary accepted by the authority having jurisdiction.

3.2 Definitions

action level: the differential between zone and outdoor CO2 concentrations, above which action is to be taken to temporarily increase outdoor air flow to the space.

adapted plants: see plants, adapted.

adequate transit service: at least two buses (including bus rapid transit), streetcars or light rail trains per hour on weekdays operating between 6:00 am and 9:00 am and between 3:00 pm and 6:00 pm or at least 5 heavy passenger rail or ferries operating between 6:00 am and 9:00 am and between 3:00 pm and 6:00 pm.

agricultural land: land that is, or was within 10 years prior to the date of the building permit application for the building project, primarily devoted to the commercial production of horticultural, viticultural, floricultural, dairy, apiary, vegetable, or animal products or of berries, grain, hay, straw, turf, seed, finfish in upland hatcheries, or livestock, and that has long-term commercial significance for agricultural production. Land that meets this definition is agricultural land regardless of how the land is zoned by the local government with zoning jurisdiction over that land.

alternate on-site sources of water: see water, alternate on-site sources of.

attic and other roofs: see ASHRAE/IESNA Standard 90.1.

authority having jurisdiction (AHJ): the agency or agent responsible for enforcing this standard.

basis of design (BOD): a document that records the concepts, calculations, decisions, and product selections used to meet the owner’s project requirements and to satisfy applicable regulatory requirements, standards, and guidelines. The document includes both narrative descriptions and lists of individual items that support the design process. (See owner's project requirements.)

biobased product: a commercial or industrial product (other than food or feed) that is composed, in whole or in significant part, of biological products or renewable agricultural materials (including plant, animal, and marine materials) or forestry materials.

bio-diverse plantings: nonhomogeneous, multiple-species plantings.

breathing zone: see ASHRAE Standard 62.1.

brownfield site: a site documented as contaminated by means of an ASTM E1903 Phase II Environmental Site Assessment or a site classified as a brownfield by a local, State, or Federal government agency.

building entrance: see ASHRAE/IESNA Standard 90.1.

building envelope: see ASHRAE/IESNA Standard 90.1.

building project: a building or group of buildings and site which utilize a single submittal for a construction permit or that are within the boundary of contiguous properties under single ownership.

carbon dioxide equivalent (CO_2e): a measure used to compare the impact of various greenhouse gases based on their global warming potential (GWP). CO_2e approximates the time-integrated warming effect of a unit mass of a given greenhouse gas, relative to that of carbon dioxide (CO_2). GWP is an index for estimating the relative global warming contribution of atmospheric emissions of 1 kg of a particular greenhouse gas compared to emissions of 1 kg of CO_2. The following GWP values are used based on a 100-year time horizon: 1 for CO_2, 23 for methane (CH_4), and 296 for nitrous oxide (N_2O).

classroom: a space primarily used for scheduled instructional activities.

clerestory: see ASHRAE/IESNA Standard 90.1.

climate zone: see Section 5.1.4 of ASHRAE/IESNA Standard 90.1.

commissioning authority (CxA): An entity identified by the owner who leads, plans, schedules, and coordinates the commissioning team to implement the building commissioning process. (See commissioning process.)

commissioning plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the building commissioning process. (See commissioning process.)

commissioning process: A quality-focused process for enhancing the delivery of a project. The process focuses upon verifying and documenting that the facility and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the owner's project requirements. (See owner’s project requirements.)

complete operational cycle: a period of time as long as one-year so as to account for climactic variations affecting outdoor water consumption.

conditioned space: see ASHRAE/IESNA Standard 90.1.

construction checklist: a form used by the contractor to verify that appropriate components are onsite, ready for installation, correctly installed, and functional.

continuous air barrier: the combination of interconnected materials, assemblies and flexible sealed joints and components of the building envelope that provide air-tightness to a specified permeability. (See building envelope.)

daylight zone:

(a) adjacent to vertical fenestration: the area illuminated by vertical glazing calculated as the daylit depth multiplied by the daylit width, where the daylit depth is 4.5 m (15 ft), or the distance on the floor, perpendicular to the glazing, to the nearest 1500 mm (60 in.) or higher permanent partition, whichever is less; and the daylit width is the width of the window plus, on each side, either 0.6 m (2 ft), the distance to a permanent partition, or one half the distance to the closest skylight or vertical fenestration, whichever is least. (See skylight, roof monitor, clerestory, tubular daylighting device, and vertical fenestration.)

(b) under skylights and tubular daylighting devices: the area illuminated by skylights calculated by adding the rough opening of the skylight plus, in each of the lateral and longitudinal dimensions of the skylight, the lesser of 70% of the floor-to-ceiling height, the distance to the nearest 1500 mm (60 in.) or higher permanent partition, or one half the horizontal distance to the edge of the closest skylight, roof monitor, clerestory window, tubular daylighting device, or vertical fenestration. (See skylight, roof monitor, clerestory, tubular daylighting device, and vertical fenestration.)

(c) under roof monitor: the area illuminated by vertical fenestration in a roof monitor calculated by adding the rough opening of the roof monitor plus in each of the lateral and longitudinal dimensions of the opening, the lesser of 70% of the floor-to-ceiling height, the distance to the nearest 1500 mm (60 in.) or higher permanent partition, or one half the horizontal distance to the edge of the closest skylight, roof monitor, clerestory window, or vertical fenestration. (See skylight, roof monitor, clerestory, tubular daylighting device, and vertical fenestration.)

(d) under clerestory: the area illuminated by vertical fenestration in a clerestory calculated as the daylit depth multiplied by the daylit width, where the daylit depth is the lesser of 70% of the floor-to-ceiling height, the distance to the nearest 1500 mm (60 in.) or higher permanent partition, or one half the horizontal distance to the edge of the closest skylight, and the daylit width is the length of the window plus the lesser of 70% of the floor-to-ceiling height, the distance to the nearest 1500 mm (60 in.) or higher permanent partition, or one half the horizontal distance to the edge of the closest skylight, roof monitor, clerestory window, or vertical fenestration in each longitudinal direction. (See skylight, roof monitor, clerestory, and vertical fenestration.)

0.7*HSkylight
Width0.7*H0.7*H0.7*HPartitionSkylight
FootprintDaylight ZoneH=Floor to
Ceiling Height

Daylight Zone Under Skylights

0.7*HDaylight
ZoneH=Floor to
Ceiling Height0.7*HL=Length of
Clerestory
Window0.7*H

Daylight Zone Under Clerestory

0.7*HClerestory
Opening
Width0.7*H0.7*H0.7*HClerestory
Opening
FootprintDaylight ZoneH=Floor to
Ceiling Height0.7*H

Daylight Zone Under Clerestory Roof Monitor

0.7*HRoof
Monitor
Width0.7*H0.7*H0.7*HRoof
Monitor
FootprintDaylight ZoneH=Floor to
Ceiling Height0.7*H

Daylight Zone Under Roof Monitor

densely occupied space: those spaces with a design occupant density greater than or equal to 15 people per 100 m2 (1000 ft2).

design minimum outdoor airflow rate: the rate of outdoor airflow provided by a ventilation system at design conditions.

designated park land: federal, state or local government owned land that is formally designated and set aside as park land or wildlife preserve.

development footprint: the total land area of a project site that will be developed with impervious surfaces constructed as part of the project such as buildings, streets, other areas that have been graded so as to be effectively impervious, and parking areas.

dwelling unit: see ASHRAE/IESNA Standard 90.1.

effective aperture for vertical fenestration (EAvf): the product of the visible transmittance of the overall vertical fenestration product (entire rough opening including glass, sash, and frame) and the vertical fenestration area as a percentage of the gross wall area. Visible transmittance is determined in accordance with ASHRAE/IESNA Standard 90.1, Section 5.8.2.6. (See fenestration area, gross wall area, and vertical fenestration.)

emergency ride home: access to transportation home in the case of a personal emergency or unscheduled overtime for employees who commute via transit, carpool or vanpool.

evapotranspiration (ET): the sum of evaporation and plant transpiration. Evaporation accounts for the movement of water to the air from sources such as the soil, canopy interception, and water bodies. Transpiration accounts for the movement of water within a plant and the subsequent loss of water as vapor through stomata in its leaves.

expressway: divided highway with a minimum of four lanes, which has controlled access for a minimum of 16 kilometers (10 miles), and a minimum posted speed of 70 km/h (45 mph).

fenestration: see ASHRAE/IESNA Standard 90.1.

fenestration area: see ASHRAE/IESNA Standard 90.1.

fish and wildlife habitat conservation area:

(a) areas with which state or federally designated endangered, threatened, and sensitive species have a primary association;

(b) naturally occurring ponds under 8 ha (20 acres) and their submerged aquatic beds that provide fish or wildlife habitat, including those artificial ponds intentionally created from dry areas in order to mitigate impacts to ponds;

(c) waters of the state, including lakes, rivers, ponds, streams, and inland waters; and

(d) lakes, ponds, streams, and rivers planted with game fish by a governmental or tribal entity.

forest land: all designated state and national forests, land that is, or was within 10 years prior to the date of the building permit for the building project, primarily devoted to growing trees for long-term commercial timber production.

generally accepted engineering standard: see ASHRAE/IESNA Standard 90.1.

greenfield site: a site of which 30% or less has been previously developed with impervious surfaces.

greyfield site: a site of which more than 30% is already developed with impervious surfaces.

gross roof area: see ASHRAE/IESNA Standard 90.1.

gross wall area: see ASHRAE/IESNA Standard 90.1.

hardscape: site paved areas including roads, driveways, parking lots, walkways, courtyards, and plazas.

heat island effect: the tendency of urban areas to be at a warmer temperature than surrounding rural areas.

high-performance green building: a building designed, constructed and capable of being operated in a manner which increases environmental performance and economic value over time, safeguards the health of occupants, and enhances satisfaction and productivity of workers through integration of environmentally-preferable building materials, and water-efficient and energy-efficient systems.

hydrozone: to divide the landscape irrigation system according to each zone's water needs based on plant materials, soil and other factors.

improved landscape: any disturbed area of the site where new plant and/or grass materials are to be used including green roofs, plantings for stormwater controls, planting boxes, and similar vegetative use. Improved landscape shall not include hardscape areas such as sidewalks, driveways, or other paved areas, and swimming pools or decking.

integrated design process/integrated project delivery: a design process utilizing early and complete collaboration amongst representatives of each stakeholder and participating consultant on the project. Unlike the conventional or linear design process, integrated design requires broad stakeholder/consultant participation.

irrigation adequacy: a representation of how well irrigation met the needs of the plant material. This reflects the percentage of required water for turf or plant material supplied by rainfall and controller-scheduled irrigations.

irrigation excess: a representation of how much irrigation water was applied beyond the needs of the plant material. This reflects the percentage of water applied in excess of 100% of required water.

landscape establishment period: a time period, beginning on the date of completion of permanent plantings and not exceeding 18 months, intended to allow the permanent landscape to become sufficiently established to remain viable.

life cycle assessment (LCA): a compilation and evaluation of the inputs, outputs, and the potential environmental impacts of a building system throughout its life cycle. LCA addresses the environmental aspects and potential environmental impacts (e.g., use of resources and environmental consequences of releases) throughout a building's life cycle from raw material acquisition through manufacturing, construction, use, operation, end-of life treatment, recycling, and final disposal (end-of-life). The purpose is to identify opportunities to improve the environmental performance of buildings throughout their life cycles.

light rail: a streetcar-type vehicle that has step entry or level boarding entry and is operated on city streets, semi-exclusive rights-of-way, or exclusive rights-of-way.

lighting power allowance: see ASHRAE/IESNA Standard 90.1.

load factor: the calculated annual electrical consumption in kWh divided by the product of the calculated annual peak electrical demand in kW and 8760 hours.

native plants: see plants, native.

non-densely occupied space: a space that is not a densely occupied space. (See densely occupied space.)

non-potable water: see water, non-potable.

nonresidential: see ASHRAE/IESNA Standard 90.1.

occupiable space: see ASHRAE Standard 62.1.

on-site renewable energy power system: photovoltaic, solar thermal, geothermal, and wind systems used to generate electrical power and located on the building site.

once-through cooling: the practice of using potable water to cool a condenser or other item of process or building equipment and then discarding of the water to a sanitation drain. Once-through cooling also includes the use of potable water to temper hot water or steam before sending it to a sanitation drain.

outdoor air: see ASHRAE Standard 62.1

owner's project requirements (OPR): a written document that details the functional requirements of a project and the expectations of how it will be used and operated. These include project goals, measurable performance criteria, cost considerations, benchmarks, success criteria, and supporting information.

permeable pavement: pervious concrete or porous asphalt that allows the movement of water and air through the paving material, and primarily used as paving for roads, parking lots and walkways. Permeable paving materials have an open-graded coarse aggregate with interconnected voids.

permeable pavers: concrete or masonry units that present a solid surface but allow natural drainage and migration of water into the base below by permitting water to drain through the spaces between the pavers.

plants:

(a) adapted (or introduced) plants: plants that reliably grow well in a given habitat with minimal attention from humans in the form of winter protection, pest protection, water irrigation, or fertilization once root systems are established in the soil. Adapted plants are considered to be low maintenance but not invasive.

(b) invasive plants: plants, both indigenous and non-indigenous species or strains, which are characteristically adaptable, aggressive, have a high reproductive capacity and tend to overrun the ecosystems in which they inhabit. Collectively they are one of the great threats to biodiversity and ecosystem stability.

(c) native (or indigenous) plants: plants that adapted to a given area during a defined time period and are not invasive. In America, the term often refers to plants growing in a region prior to the time of settlement by people of European descent.

porous pavers (open-grid pavers): concrete or masonry units where at least 40% of the surface area consists of holes or openings that are filled with sand, gravel, other porous material, or vegetation.

post-consumer recycled content: proportion of recycled material in a product generated by households or by commercial, industrial and institutional facilities in their role as end-users of the product, which can no longer be used for its intended purpose. This includes returns of material from the distribution chain. (See recycled material.)

potable water: see water, potable.

pre-consumer recycled content: proportion of recycled material in a product diverted from the waste stream during the manufacturing process. Content that shall not be considered pre-consumer recycled includes the re-utilization of materials such as rework, regrind or scrap generated in a process and capable of being reclaimed within the same process that generated it. (See recycled material.)

projection factor (PF): see ASHRAE/IESNA Standard 90.1.

projection factor, interior: the ratio of the horizontal depth of the interior shading projection divided by the sum of the height of the fenestration and the distance from the bottom of the fenestration to the top of the farthest point of the interior shading projection, in consistent units.

recovered material: material that would have otherwise been disposed of as waste or used for energy recovery (e.g. incinerated for power generation), but has instead been collected and recovered as a material input, in lieu of new primary material, for a recycling or a manufacturing process.

recycled content: proportion, by mass, of recycled material in a product or packaging. Only pre-consumer and post-consumer materials shall be considered as recycled content. (See recycled material.)

recycled material: material that has been reprocessed from recovered (reclaimed) material by means of a manufacturing process and made into a final product or into a component for incorporation into a product. (See recovered material.)

residential: see ASHRAE/IESNA Standard 90.1.

roof: see ASHRAE/IESNA Standard 90.1.

roof area, gross: see ASHRAE/IESNA Standard 90.1.

roof monitor: a raised central portion of a roof having vertical fenestration.

semiheated space: see ASHRAE/IESNA Standard 90.1.

service overcurrent protection device rating: the fuse or circuit breaker rating in kVA specified to protect the service entrance conductors to the building. The rating shall be converted to kVA by multiplying the device ampere rating by the service supply voltage. For circuit breakers with adjustable trip settings or replaceable trip units, the rating shall be the actual setting or trip unit of the circuit breaker specified. Where the service entrance conductors are protected by multiple overcurrent devices or the building has more than one service, the service overcurrent protection device rating shall be the combined ratings of all such devices.

service water heating: see ASHRAE/IESNA Standard 90.1.

sidelighting: daylighting provided by vertical fenestration mounted below the ceiling plane.

single-rafter roof: see ASHRAE/IESNA Standard 90.1.

skylight: see ASHRAE/IESNA Standard 90.1.

site: a contiguous area of land that is under the ownership or control of one entity.

smart controller (weather-based irrigation controller): a device that estimates or measures depletion of water from the soil moisture reservoir and operates an irrigation system to replenish water as needed while minimizing excess.

solar energy system: any device or combination of devices or elements which rely upon direct sunlight as an energy source, including but not limited to any substance or device which collects sunlight for use in:

(a) the heating or cooling of a structure or building;

(b) the heating or pumping of water;

(c) industrial, commercial, or agricultural processes; or

(d) the generation of electricity.

solar heat gain coefficient (SHGC): see ASHRAE/IESNA Standard 90.1.

solar reflectance index (SRI): a measure of a constructed surface's ability to reflect solar heat, as shown by a small temperature rise. A standard black surface (reflectance 0.05, emittance 0.90) is 0 and a standard white surface (reflectance 0.80, emittance 0.90) is 100.

toplighting: daylighting provided by fenestration mounted above the ceiling plane, including skylights, tubular daylighting devices, and vertical fenestration in roof monitors; and fenestration mounted above a lower adjacent ceiling plane in the space in clerestories.

tubular daylighting device: a means to capture sunlight from a rooftop. Sunlight is then redirected down from a highly reflective shaft and diffused throughout interior space.

turfgrass: grasses that are regularly mowed and, as a consequence, form a dense growth of leaf blades and roots.

vendor: a company that furnishes products to project contractors and/or subcontractors for on-site installation.

variable air volume: see ASHRAE/IESNA Standard 90.1.

verification: The process by which specific documents, components, equipment, assemblies, systems, and interfaces among systems are confirmed to comply with the criteria described in the owner’s project requirements. (See owner’s project requirements.)

vertical fenestration: see ASHRAE/IESNA Standard 90.1.

wall: see ASHRAE/IESNA Standard 90.1.

wall area, gross: see ASHRAE/IESNA Standard 90.1.

water, alternate on-site sources of: alternate on-site sources of water include, but are not limited to:

(a) rainwater or stormwater harvesting;

(b) air conditioner condensate;

(c) gray water from interior applications and treated as required;

(d) swimming pool filter backwash water;

(e) cooling tower blowdown water;

(f) foundation drain water;

(g) industrial process water; or

(h) on-site wastewater treatment plant effluent.

water, non-potable: water that is not potable water. (See potable water.)

water, potable: water from public drinking water systems or from natural freshwater sources such as lakes, streams, and aquifers where water from such natural sources would or could meet drinking water standards.

water factor (WF):

(a) clothes washer (residential & commercial: the quantity of water in L (gal) used to wash each m3 (ft3) of machine capacity.

(b) residential dishwasher: the quantity of water use in L (gal) per full machine wash and rinse cycle.

wetlands: those areas, designated in accordance with the United States Army Corps of

Engineers' Wetland Delineation Manual, that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation adapted for life in saturated soil conditions.

yearly average day-night average sound levels: level of the time-mean-square A-weighted sound pressure averaged over a one-year period with ten dB added to sound levels occurring in each night-time period from 2200 hours to 0700 hours, expressed in dB.

zone primary airflow: see ASHRAE Standard 62.1.

3.3 Abbreviations and Acronyms

AC alternating current

AHJ authority having jurisdiction

ASHRAE American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

ASME American Society of Mechanical Engineers

ASTM American Society for Testing and Materials

BOD basis of design

Btu British thermal unit

CBECS Commercial Building Energy Consumption Survey

CDHS California Department of Health Services

CEC California Energy Commission

CFC chlorofluorocarbon

cfm ft3/min

ci continuous insulation

CIE Commission Internationale de L'Eclairage (International Commission on Illumination)

CITES Convention on International Trade in Endangered Species of Wild Fauna and Flora

cm centimeter

CO2 carbon dioxide

CO2e carbon dioxide equivalent

CSA Canadian Standards Association

CxA commissioning authority

dB decibel

DB dry-bulb

DC direct current

DX direct expansion

EAvf effective aperture for vertical fenestration

EPAct U.S. Energy Policy Act

ESC erosion and sedimentation control

ETo evapotranspiration

ETS environmental tobacco smoke

fc footcandle

FF&E fit-out furniture and equipment

ft foot

gal gallon

gpm gallons per minute

GWP global warming potential

GWPr global warming potential of refrigerant

h hour

ha hectare

HCFC hydrochlorofluorocarbon

HVAC heating, ventilation, and air-conditioning

HVAC&R heating, ventilation, air-conditioning, and refrigeration

I-P inch-pound

IA Irrigation Association

IAQ indoor air quality

IEQ indoor environmental quality

IESNA Illuminating Engineering Society of North America

in. inch

kg kilogram

kL kiloliter

km kilometer

kVA kilovolt-ampere

kW kilowatt

kWh kilowatt-hour

L liter

Lr refrigerant leakage rate

lb pound

LCA life cycle assessment

LCGWP lifecycle direct global warming potential

LCODP lifecycle ozone depletion potential

LID low impact development

LPD lighting power density

m meter

M&V measurement and verification

mcg (μg) microgram

MCWB maximum coincident wet-bulb

MDF medium density fiberboard

MERV minimum efficiency reporting value

mi mile

min minute

mm millimeter

mph miles per hour

Mr end-of-life refrigerant loss

NAECA National Appliance Energy Conservation Act

NC noise criterion

O&M operation and maintenance

ODPr ozone deletion potential of refrigerant

OITC outdoor-indoor transmission class

OPR owner’s project requirements

Pa Pascal

PF projection factor

ppb parts per billion

ppm parts per million

Qtotal total cooling capacity of all HVAC or refrigeration

Qunit cooling capacity of an individual HVAC or refrigeration unit

Rc refrigerant charge

s second

SCAQMD South Coast Air Quality Management District

SCS Scientific Certification Systems

SHGC solar heat gain coefficient

SMACNA Sheet Metal and Air Conditioning Contractors National Association

SOV single occupancy vehicle

SRI solar reflectance index

STC sound transmission class

TMP transportation management plan

USDA United States Department of Agriculture

USDOE United States Department of Energy

USEPA United States Environmental Protection Agency

USFEMA United States Federal Emergency Management Agency

USGPO United States Government Printing Office

USGSA United States General Services Administration

VAV variable air volume

VOC volatile organic compound

WB wet-bulb

WF water factor

yr year

4. ADMINISTRATION AND ENFORCEMENT

4.1 General. Building projects shall comply with Sections 4 through 11. Within each of those Sections, building projects shall comply with all Mandatory Provisions (x.3); and, where offered, either

(a) Prescriptive Option (x.4), or

(b) Performance Option (x.5).

4.1.1 Normative Appendices. The normative appendices to this standard are considered to be integral parts of the mandatory requirements of this standard, which for reasons of convenience, are placed apart from all other normative elements.

4.1.2 Informative Appendices. The informative appendices to this standard and informative notes located within this standard contain additional information and are not mandatory or part of this standard.

5. SITE SUSTAINABILITY

5.1 Scope. This section addresses requirements for building projects that pertain to site selection, site development, mitigation of heat island effect, and light pollution reduction.

5.2 Compliance. The site shall comply with 5.3, Mandatory Provisions; and either

(a) 5.4, Prescriptive Option, or

(b) 5.5, Performance Option.

5.3 Mandatory Provisions

5.3.1 Site Selection. The building project shall comply with 5.3.1.1 and 5.3.1.2.

5.3.1.1 Allowable Sites. The building project shall take place on one of the following:

(a) in an existing building envelope.

(b) on a brownfield site.

(c) on a greyfield site.

(d) on a greenfield site that is within 800 m (1/2 mi) of residential land that is developed, or is under construction, at an average density of 4 units per ha (10 units per acre) net unless that site is agricultural land or forest land. Proximity is determined by drawing a circle with an 800 m (1/2 mi) radius around the center of the proposed site.

(e) on a greenfield site that is within 800 m (1/2 mi) of a minimum of 10 Basic Services and that has pedestrian access between the building and the services unless that site is agricultural land or forest land. Basic Services include, but are not limited to: 1) financial institution; 2) place of worship; 3) convenience grocery; 4) day care; 5) dry cleaners; 6) fire station; 7) beauty; 8) hardware; 9)laundromat; 10) library; 11) medical/dental; 12) senior care facility; 13) park; 14) pharmacy; 15) post office; 16) restaurant; 17) school; 18) supermarket; 19) theater; 20) community center; 21) fitness center; 22) museum; 23) local government facility. Proximity is determined by drawing a circle with an 800 m (1/2 mi) radius around the center of the proposed site.

(f) on a greenfield site that is either within 800 m (1/2 mi) of an existing, or planned and funded, commuter rail, light rail or subway station or within 400 m (1/4 mi) of adequate transit service useable by building occupants unless that site is agricultural land or forest land. Proximity is determined by drawing a circle with an 800 m (1/2 mi) radius around the center of the proposed site.

(g) on a greenfield site that is agricultural land and the building's purpose is related to the agricultural use of the land.

(h) on a greenfield site that is forest land and the building's purpose is related to the forestry use of the land.

(i) on a greenfield site that is designated park land and the building's purpose is related to the use of the land as a park.

5.3.1.2 Prohibited Development Activity. There shall be no site disturbance or development of the following:

(a) previously undeveloped land having an elevation lower than 1.5 m (5 ft) above the elevation of the 100 year flood as defined by USFEMA.

(b) within 50 m (150 ft) of any fish and wildlife habitat conservation area unless the site disturbance or development involves plantings or habitat enhancement of the functions and values of the area.

(c) within 25 m (75 ft) of any wetland unless the site disturbance or development involves plantings or habitat enhancement of the functions and values of the wetland.

Exception to 5.3.1.2: Development of a low-impact trail exclusively designed for pedestrians is allowed within 4.5 m (15 ft) of a fish and wildlife habitat conservation area or wetland.

5.3.2 Mitigation of Heat Island Effect.

5.3.2.1 Site Hardscape. Not less than 50% of the site hardscape shall be provided with any combination of the following. The site hardscape includes roads, sidewalks, courtyards, and parking lots but not the constructed building surfaces nor portion of the site hardscape covered by photovoltaic panels generating electricity or other solar energy systems used for space heating or water heating:

(a) bio-diverse plantings of native plants and adapted plants (trees and vegetation) planted to provide shade within 5 years of issuance of the final certificate of occupancy. The effective shade coverage shall be the arithmetic mean of the shade coverage calculated at 10 am, noon, and 3pm on the summer solstice.

(b) paving materials with a minimum initial solar reflective index (SRI) of 29. A default SRI value of 35 for new concrete without added color pigment is allowed to be used in lieu of measurements.

(c) porous pavers (open-grid pavers) .

(d) shading through the use of structures, provided that the top surface of the shading structure complies with the provisions of 5.3.2.3.

(e) parking under a building, provided that the roof of the building complies with the provisions of 5.3.2.3.

Exception to 5.3.2.1: Building projects in climate zones 6, 7 and 8.

5.3.2.2 Walls. Above-grade building walls and retaining walls shall be shaded in accordance with this section. The building is allowed to be rotated up to 45 degrees to the nearest cardinal orientation for purposes of calculations and showing compliance. Compliance with this section is allowed to be achieved through the use of shade-providing plants, man-made structures, existing buildings, hillsides, permanent building projections, or a combination of these, using the following criteria:

(a) shade shall be provided on at least 30% of the east and west above-grade walls and retaining walls from grade level to a height of 6 m (20 ft) above-grade or the top of the exterior wall, whichever is less, within 5 years of issuance of the final certificate of occupancy. Shade coverage shall be calculated at 10 am for the east walls and 3 pm for the west walls on the summer solstice.

(b) where shading is provided by vegetation, vegetation (including trees) shall be bio-diverse plantings of native plants and adapted plants and appropriately sized, selected, planted and maintained so that they do not interfere with overhead power lines or underground water and sewer lines. Such trees shall be placed a minimum of 1.5 m (5 ft) from and within 15 m (50 ft) of the building or retaining wall.

Exceptions to 5.3.2.2:

(a) The requirements of this section are satisfied if 75% or more of the opaque wall surfaces on the east and west have a minimum SRI of 29. Each wall is allowed to be considered separately for this exception.

(b) East wall shading is not required for buildings located in climate zones 5, 6, 7 and 8. West wall shading is not required for buildings located in climate zones 7 and 8.

(c) Portions of walls that are used for renewable energy power systems shall count toward the required shaded area.

5.3.2.3 Roofs. This section applies to the building and covered parking roof surfaces. A minimum of 75% of the entire roof surface not used for roof penetrations, renewable energy power systems (e.g. photovoltaics or solar thermal collectors), harvesting systems for rainwater to be used on-site, or green roofing systems shall be covered with products that comply with one or more of the following:

(a) have a minimum initial SRI of 78 for a low-sloped roof (a slope less than or equal to 2:12) and a minimum initial SRI of 29 for a steep-sloped roof (a slope of more than 2:12).

(b) comply with the criteria for the USEPA’s Energy Star Program Requirements for Roof Products – Eligibility Criteria.

Exceptions to 5.3.2.3:

(a) Building projects in climate zones 6, 7, and 8.

(b) Building projects where an annual energy analysis simulation demonstrates that the total annual building energy cost and total annual CO2e, as calculated in accordance with 7.5.2 and 7.5.3, are both 2% less for the proposed roof than with a roof material complying with the requirements of 5.3.2.3(a).

(c) Roofs used to shade or cover parking and roofs over semi-heated spaces provided that they have a minimum initial SRI of 29. A default SRI value of 35 for new concrete without added color pigment is allowed to be used in lieu of measurements.

5.3.2.4 Solar Reflective Index. The solar reflective index (SRI) shall be calculated in accordance with ASTM E1980 for medium-speed wind conditions. The SRI shall be based upon solar reflectance as measured in accordance with ASTM E1918 or ASTM C1549, and the thermal emittance as measured in accordance with ASTM E408 or ASTM C1371. For roofing products, the values for solar reflectance and thermal emittance shall be determined by a laboratory accredited by a nationally recognized accreditation organization, such as the Cool Roof Rating Council CRRC-1 Product Rating Program, and shall be labeled and certified by the manufacturer. For building materials other than roofing products, the values for solar reflectance and thermal emittance shall be determined by an independent third party.

5.3.3 Reduction of Light Pollution

5.3.3.1 Outdoor Lighting Trespass Limits. Outdoor lighting shall be designed so that all site and building-mounted luminaires produce a maximum initial illuminance no greater than indicated in Table 5.3.4.1.

Exceptions to 5.3.3.1:

(a) Illuminance generated from a single luminaire placed at the intersection of a private vehicular driveway and public roadway accessing the site, is allowed to use the centerline of the public roadway as a boundary condition in Table5.3.3.1.

(b) Alternatively, in Lighting Zones 2, 3, and 4 for site boundaries that abut public roadways, light trespass requirements in Table 5.3.3.1 are allowed to be relative to the curb line shared by the public right-of-way and the site instead of the site boundary.

Table 5.3.3.1

Outdoor Lighting Trespass Limits1

Lighting

Zone

1

Lighting

Zone

2

Lighting
Zone

3

Lighting
Zone

4

Horizontal and vertical
illuminance at boundary
in lux (fc)

0.1 (0.01)

1.0 (0.10)

2.0 (0.20)

6.0 (0.60)

Max. percentage of initial
designed fixture lumens
emitted 90 degrees or higher

0%

2%

5%

10%

1 Lighting Zone 1: Designated park land and forest land.

Lighting Zone 2: Areas consisting of residential zoning, neighborhood business districts, light industrial with limited nighttime use, and residential mixed use areas.

Lighting Zone 3: All other areas.

Lighting Zone 4: Special districts as defined by local jurisdiction for high intensity nighttime use.

5.4 Prescriptive Option.

5.4.1 Site Development. Building projects shall comply with 5.4.1.1 and 5.4.1.2.

5.4.1.1: Effective Pervious Area for All Sites: A minimum of 40% of the entire site shall incorporate one or any combination of the following:

(a) shall be vegetated with a minimum depth of growing medium of 300 mm (12 in.) Such vegetated areas include bioretention facilities, raingardens, filter strips, grass swales, vegetated level spreaders, constructed wetlands, planters, or open space with plantings. At least 60% of the vegetated area shall consist of biodiverse planting of native plants or adapted plants,

(b) shall have a vegetated roof with a minimum depth of growing medium of 75 mm (3 in.),

(c) shall have porous pavers (open grid pavers),

(d) shall have permeable pavement or permeable pavers with a minimum percolation rate of 100 L/min·m2 (2 gal/min·ft2) and a minimum of 150 mm (6 in.) of open-graded base below the pavement or pavers.

Exceptions to 5.4.1.1:

(a) The effective pervious surface is allowed to be reduced to a minimum of 20% of the entire site if 10% of the annual rainfall for the entire development footprint is captured on site and reused for site water use or building water use.

(b) The effective pervious surface is not required if 50% of the annual rainfall for the entire development footprint is captured on site and reused for site water use or building water use.

(c) Locations with less than 250 mm (10 in.) of rain per year.

(d) Building projects on a brownfield site.

5.4.1.2 Greenfield Sites: On a greenfield site:

(a) where more than 20% of the area of the predevelopment site has existing native plants or adapted plants, a minimum of 20% of the area of native plants or adapted plants shall be retained.

(b) where 20% or less of the area of the predevelopment site has existing native plants or adapted plants, a minimum of 20% of the site shall be developed or retained as vegetated area. Such vegetated areas include bioretention facilities, raingardens, filter strips, grass swales, vegetated level spreaders, constructed wetlands, planters, or open space with plantings. A minimum of 60% of such vegetated area shall consist of biodiverse planting of native plants or adapted plants.

5.5 Performance Option.

5.5.1 Site Development: Building projects shall comply with the following:

(a) If the project is in an existing building envelope, a minimum of 20% of the average annual rainfall on the development footprint shall be managed through infiltration, reuse, or evapotranspiration.

(b) If the project is not in an existing building envelope, but is on a greyfield site, a minimum of 40% of the average annual rainfall on the development footprint shall be managed through infiltration, reuse, or evapotranspiration.

(c) For all other sites, a minimum of 70% of the average annual rainfall on the development footprint shall be managed through infiltration, reuse, or evapotranspiration.

6. WATER USE EFFICIENCY

6.1 Scope. This section specifies requirements for potable and non-potable water use efficiency, both for the site and for the building, and water metering.

6.2 Compliance. The water systems shall comply with 6.3, Mandatory Provisions; and either

(a) 6.4, Prescriptive Option, or

(b) 6.5, Performance Option.

Site water use and building water use are not required to use the same option, i.e. Prescriptive or Performance, for demonstrating compliance.

6.3 Mandatory Provisions

6.3.1 Site Water Use Reduction

6.3.1.1 Landscape Design. A minimum of 60% of the area of the improved landscape shall be in bio-diverse planting of native plants and adapted plants other than turfgrass.

Exception to 6.3.1.1: The area of dedicated athletic fields (e.g. baseball, football, soccer, but excluding golf courses and driving ranges) shall be excluded from the calculation of the improved landscape for schools, residential common areas, or public recreational facilities.

6.3.1.2 Irrigation System Design. Hydrozoning of automatic irrigation systems to water different plant materials such as turfgrass vs. shrubs is required.

6.3.1.3 Controls. Any irrigation system for the project site shall be controlled by a smart controller that uses evapotranspiration and weather data to adjust irrigation schedules and that complies with the minimum requirements as listed below when tested in accordance with IA SWAT Climatological Based Controllers 7th Draft Testing Protocol. All such control systems shall also incorporate an on-site rain or moisture sensor that automatically shuts the system off after a predetermined amount of rainfall or sensed moisture in the soil.

(a) Irrigation adequacy – 80 percent minimum ET.

(b) Irrigation excess – not to exceed 10 percent.

Exception to 6.3.1.3: A temporary irrigation system used exclusively for the establishment of new landscape shall be exempt from this requirement. Temporary irrigation systems shall be removed or permanently disabled at such time as the landscape establishment period has expired.

6.3.2 Building Water Use Reduction

6.3.2.1 Plumbing Fixtures and Fittings. Plumbing fixtures (water closets and urinals) and fittings (faucets and showerheads) shall comply with the following requirements:

(a) Water closets (toilets) – flushometer valve type: For single flush, maximum flush volume when determined in accordance with ASME A112.19.2 – 4.8 L (1.28 gal). For dual-flush, effective flush volume determined in accordance with ASME A112.19.4 and Section 3.2, USEPA WaterSense Tank-Type High Efficiency Toilet Specification – 4.8 L (1.28 gal).

(b) Water closets (toilets) – tank-type: Tank-type water closets shall comply with the performance criteria of the U.S. EPA WaterSense Tank-Type High-Efficiency Toilet Specification.

(c) Urinals: Maximum flush volume when determined in accordance with ASME A112.19.2 – 1.9 L (0.5 gal). Non-water urinals shall comply with ASME A112.19.19 (vitreous china) or IAPMO Z124.9 (plastic) as appropriate.

(d) Public lavatory faucets: Maximum flow rate –1.9 L/min (0.5 gal/min) when tested in accordance with ASME A112.18.1/CSA B125.1.

(e) Public metering self-closing faucet: Maximum water use – 1.0 L (0.25 gal) per metering cycle when tested in accordance with ASME A112.18.1/CSA B125.1.

(f) Residential bathroom lavatory sink faucets: Maximum flow rate – 5.7 L/min (1.5 gal/min) when tested in accordance with ASME A112.18.1/CSA B125.1. Residential bathroom lavatory sink faucets shall comply with the performance criteria of the USEPA WaterSense High-Efficiency Lavatory Faucet Specification.

(g) Residential kitchen faucets: Maximum flow rate – 8.3 L/min (2.2 gal/min) when tested in accordance with ASME A112.18.1/CSA B125.1.

(h) Residential showerheads: Maximum flow rate – 7.6 L/min (2.0 gal/min) when tested in accordance with ASME A112.18.1/CSA B125.1.

(i) Residential shower compartment (stall) in dwelling units and guest rooms: The allowable flow rate from all shower outlets (including rain systems, waterfalls, bodysprays, and jets) that can operate simultaneously shall be limited to a total of 7.6 L/min (2.0 gal/min).

Exceptions to 6.3.2.1(i):

(a) Showers that emit recirculated non-potable water originating from within the shower compartment while operating are allowed to exceed the maximum if the total potable water flow does not exceed the flow rate specified in 6.3.2.1(i).

(b) Where the area of a shower compartment exceeds 1.9 m2 (3,000 in2), an additional flow of 7.6 L/min (2.0 gal/min) shall be permitted for each multiple of 1.9 m2 (3,000 in2) of floor area or fraction thereof.

6.3.2.2 Appliances.

(a) Clothes washers and dishwashers installed within dwelling units shall comply with the USEPA Energy Star Program Requirements for Clothes Washers and Energy Star Program Requirements for Dishwashers. Maximum water use shall be as follows:

1. Clothes Washers – maximum of 800 L/m3 of drum capacity (6.0 gal/ft3 of drum capacity)

2. Dishwashers – maximum WF of 22 L/full operating cycle (5.8 gal/full operating cycle).

(See also the energy efficiency requirements in 7.4.7(c).)
(b) Clothes washers installed in publicly accessible spaces (e.g. multifamily and hotel common areas) and coin- and card-operated clothes washers of any size used in laundromats shall have a maximum WF of 1.0 kL/m3of drum capacity-normal cycle (7.5 gal/ft3 of drum capacity-normal cycle). (See also the energy efficiency requirements in 7.4.7(c) and 7.4.7(d).)

6.3.2.3 HVAC Systems and Equipment.

(a) Once-through cooling with potable water is prohibited.

(b) Cooling towers and evaporative coolers shall be equipped with makeup and blowdown meters, conductivity controllers and overflow alarms. Cooling towers shall be equipped with efficient drift eliminators that achieve drift reduction to 0.002 percent of the circulated water volume for counterflow towers and 0.005% for cross-flow towers. (See also Table C-15.)

(c) Condensate from air conditioning units with a capacity greater than 19 kW (65,000 Btuh) and from all steam systems shall be recovered for re-use.

6.3.2.4 Roofs. The use of potable water to spray roofs for thermal conditioning purposes or irrigation of vegetated roofs is prohibited.

6.3.3 Water Metering

6.3.3.1 Meters. The domestic water supply (both potable and reclaimed) entering the building project shall be metered. In addition, for individual leased, rented, or other tenant or sub-tenant space within any building totaling in excess of 5,000 m2 (50,000 ft2) or if the space or any part thereof is used for a laundry/cleaners operation, restaurant/food service, medical/dental office, laboratory, or beauty salon/barbershop, separate submeters shall be provided. For buildings that use evaporative cooling, cooling tower(s), hot water makeup systems, or automatic landscape irrigation system(s), separate submeters shall be provided for each such application. Any project or building, or tenant or sub-tenant space within a project or building, such as a commercial car wash or aquarium, shall be submetered where consumption is projected to exceed 3,800 L (1,000 gal) per day.

Meters with remote metering capability or automatic meter reading (AMR) capability shall be provided to collect water use data for each water supply source (e.g. potable water, reclaimed water, rainwater) to the project that exceeds the thresholds listed in Table 6.3.3-1. Utility company service entrance/interval meters are allowed to be used provided they are configured for automatic meter reading (AMR) capability.

Table 6.3.3-1 Water Supply Source Meter Thresholds.

Water Source	Main Metering Threshold
Potable Water	3,800 L/day (1,000 gal/day)

Municipally reclaimed water

3,800 L/day (1,000 gal/day)

Alternate sources of water

1,900 L/day (500 gal/day)

Sub-metering with remote metering or AMR capability shall be provided to collect water use data for each of following building subsystems, if they are sized above the threshold levels listed in Table 6.3.3-2:

Table 6.3.3-2 Subsystem Water Metering Thresholds

Subsystem

Sub-Metering Threshold

Cooling Towers

Primary flow > 30 L/s (500 gpm)

Evaporative Coolers

Makeup water > 0.04 L/s (0.6 gpm)

Steam and hot-water boilers

> 50 kW (500,000 Btu/h) input

Irrigated landscape area with controllers

> 2,500 m2 (25,000 ft2)

Separate campus or project buildings

Consumption > 3,800 L/day (1,000 gal/day)

Separately leased or rental space

Consumption > 3,800 L/day (1,000 gal/day)

Any large water using process

Consumption > 3,800 L/day (1,000 gal/day)

6.3.3.2 Meter Data Collection. All building meters and sub-meters installed to comply with the thresholds limits in 6.3.3.1 shall be configured to communicate water consumption data to a meter data management system. Meters shall provide data a minimum of daily and shall record a minimum of hourly consumption of water.

6.3.3.3 Data Storage and Retrieval. The meter data management system shall be capable of electronically storing water meter and sub-meter data and creating user reports showing calculated hourly, daily, monthly and annual water consumption for each meter and sub-meter and provide alarming notification capabilities as needed to support the requirements of the Water Efficiency Measurement and Verification plan in 10.3.3.2.

6.4 Prescriptive Option

6.4.1 Site Water Use Reduction. For golf courses and driving ranges, only municipally-reclaimed water and/or alternate on-site sources of water shall be used to irrigate the landscape. For other landscaped areas, a maximum of one-third of improved landscape area is allowed to be irrigated with potable water. The area of dedicated athletic fields (e.g., baseball, softball, football, soccer, but not a golf course or driving range) shall be excluded from the calculation of the improved landscape for schools, residential common areas, or public recreational facilities. All other irrigation shall be provided from alternate on-site sources of water or municipally-reclaimed water.

Exceptions to 6.4.1: Potable water is allowed to be temporarily used on such newly installed landscape for the landscape establishment period. The amount of potable water that may be applied to the newly planted areas during the temporary landscape establishment period shall not exceed 70% of ETo for turfgrass and 55% of ETo for other plantings. If municipally-reclaimed water is available at a water main within 60 m (200 ft) of the project site, it shall be used in lieu of potable water during the landscape establishment period. After the landscape establishment period has expired, all irrigation water use shall comply with the requirements established elsewhere in this standard.

6.4.2 Building Water Use Reduction.

6.4.2.1 Cooling Towers. The water being discharged for cooling towers for air conditioning systems such as chilled water systems shall be limited in accordance with (a) or (b):

(a) for makeup waters having less than 200 mg/L (200 ppm) of total hardness expressed as calcium carbonate, by achieving a minimum of five (5) cycles of concentration based on a ratio of the conductivity of the water being discharged (blowdown) divided by the conductivity of the feed (makeup) water(s);

(b) for makeup waters with more than 200 mg/L of total hardness expressed as calcium carbonate, by achieving a minimum of 3.5 cycles of concentration based on a ratio of the conductivity of the water being discharged (blowdown) divided by the conductivity of the feed (makeup) water(s).

Exception to 6.4.2.1: Where the blowdown's total dissolved solids concentration exceeds 1,500 mg/L (1500 ppm), or silica exceeds 150 mg/L (150 ppm) of silica measured as silicon dioxide before the above cycles of concentration are reached.

6.4.2.2 Commercial Food Service Operations. Commercial food service operations (e.g. restaurants, cafeterias, food preparation kitchens, caterers, etc.):

(a) shall use high-efficiency pre-rinse spray valves (i.e. valves which function at 4.9 L (1.3 gal) per minute or less and comply with a 26-second performance requirement when tested in accordance with ASTM F2324),

(b) shall use dishwashers that comply with the requirements of the USEPA Energy Star Program for Commercial Dishwashers,

(c) shall use boilerless/connectionless food steamers that consume no more than 7.5 L (2.0 gal) per hour in the full operational mode,

(d) shall use combination ovens that consume not more than 38 L/min (10 gpm) in the full operational mode,

(e) shall use air-cooled ice machines that comply with the requirements of the USEPA Energy Star Program for Commercial Ice Machines, and

(f) shall be equipped with hands-free faucet controllers (foot controllers, sensor-activated, or other) for all faucet fittings within the food preparation area of the kitchen and the dish room, including pot sinks and washing sinks.

6.4.2.3 Medical and Laboratory Facilities. Medical and laboratory facilities (e.g. clinics, hospitals, medical centers, physician and dental offices, and medical and non-medical laboratories of all types):

(a) shall use water-efficient steam sterilizers that use (1) water tempering devices that only allow water to flow when the discharge of condensate or hot water from the sterilizer exceeds 60 C (140 °F) and (2) mechanical vacuum equipment in place of venturi-type vacuum systems for vacuum sterilizers,

(b) shall use film processor water recycling units where large frame x-ray films of more than 150 mm (6 in.) in either length or width are processed (small dental x-ray equipment is exempt from this requirement),

(c) shall use digital imaging and radiography systems where the digital networks are installed (as opposed to conventional film-based systems),

(d) shall use a dry-hood scrubber system or, if the applicant determines that a wet-hood scrubber system is required, the scrubber shall be equipped with a water recirculation system. For perchlorate hoods and other applications where a hood wash-down system is required, the hood shall be equipped with self-closing valves on those wash-down systems,

(e) shall use dry vacuum pumps, unless fire and safety codes for explosive, corrosive or oxidative gasses requires a liquid ring pump, and,

(f) shall use efficient water treatment systems that comply with the following criteria:

1. for all filtration processes, pressure gauges shall determine and display when to backwash or change cartridges;

2. for all ion exchange and softening processes, recharge cycles shall be set by volume of water treated or based upon conductivity or hardness;

3. for reverse osmosis and nanofiltration equipment, reject water shall not exceed 60 % of the feed water and shall be used as scrubber feed water or other beneficial uses on the project site.

Exception to 6.4.2.3: Food service operations within medical facilities shall comply with 6.4.2.2.

6.4.3 Special Water Features. Water use shall comply with the following:

(a) Ornamental fountains and other ornamental water features shall be supplied either by alternate on-site sources of water or by municipally-reclaimed water delivered by the local water utility acceptable to the authority having jurisdiction. Fountains and other features shall be equipped with: (1) make-up water meters (2) leak detection devices that shut off water flow if a leak of more than 3.7 L (1.0 gal) per hour is detected, and (3) equipment to recirculate, filter, and treat all water for reuse within the system.

Exception to 6.4.3(a): Where alternate on-site sources of water or municipally-reclaimed water are not available within 150 m (500 ft) of the building project site, potable water is allowed to be used for start-up and make-up water.

(b) Pools and spas:

1. Backwash water: recover filter backwash water for reuse on landscaping or other applications, or treat and reuse backwash water within the system.

2. Filtration: For filters with removable cartridges, only reusable cartridges and systems shall be used. For filters with backwash capability, use only pool filter equipment that includes (a) a pressure drop gauge to determine when the filter

needs to be backwashed and (b) a sight glass enabling the operator to determine when to stop the backwash cycle.

3. Pool splash troughs, if provided, shall drain back into the pool system.

6.5 Performance Option. Calculations shall be done in accordance with generally accepted engineering standards and handbooks acceptable to the authority having jurisdiction.

6.5.1 Site Water Use Reduction. Potable water (and municipally-reclaimed water, where used) consumption for the irrigation of improved landscape shall not exceed 35% of baseline evapotranspiration for that area of the country where the baseline is equal to 70% of ETo for turfgrass areas and 55% of ETo for all other plant material after adjustment for rainfall.

6.5.2 Building Water Use Reduction. The building project shall have an annual interior water use less than that achieved by compliance with 6.3.2, 6.4.2, and 6.4.3.

7. ENERGY EFFICIENCY

7.1 Scope. This section specifies requirements for energy efficiency for buildings and appliances, for on-site renewable energy power systems, and for energy metering.

7.2 Compliance. The energy systems shall comply with 7.3, Mandatory Provisions; and either

(a) 7.4, Prescriptive Option, or

(b) 7.5, Performance Option.

7.3 Mandatory Provisions

7.3.1 General. Building projects shall be designed to comply with Sections 5.4, 6.4, 7.4, 8.4, 9.4 and 10.4 of ASHRAE/IESNA Standard 90.1.

7.3.2 On-site Renewable Energy Power Systems. Building projects shall contain on-site renewable energy power systems with an electrical rating not less than 1.0% of the service overcurrent protection device rating. The rating of the on-site renewable energy power system shall be the nameplate rating in kVA (dc).

Exceptions to 7.3.2:

(a) Building projects with an on-site solar water heating system that provides 100% of the domestic hot water needs or has a peak capacity equivalent to not less than 2.5 % of the service overcurrent protection device rating for the building project. The system shall be certified in accordance with SRCC OG-100.

(b) Building projects that demonstrate compliance using the Performance Option in 7.5 and provide any combination of energy cost and CO_2e savings achieving a minimum of 10.0% total.

7.3.3 Energy Metering

7.3.3.1 Meters. Meters with remote metering capability or automatic meter reading (AMR) capability shall be provided to collect energy use data for each supply energy source (e.g. gas, electricity, district steam) to the building that exceed thresholds listed in Table 7.3.3-1. Utility company service entrance/interval meters are allowed to be used provided they are configured for automatic meter reading (AMR) capability.

Table 7.3.3-1 Energy Source Meter Thresholds

Energy Source	Main Metering Threshold
Electrical service	> 200 kVA
On-site renewable energy power	All systems > 1 kVA (peak)
Gas and steam service	> 300 kW (1,000,000 Btu/h)
Geothermal	> 300 kW (1,000,000 Btu/h) heating

Solar thermal	> 10 kW (30,000 Btu/h)

Sub-metering with remote metering capability shall be provided to collect energy use data for each subsystem component in accordance with Table 7.3.3-2:

Table 7.3.3-2 Component Energy Metering Thresholds

Component	Sub-Metering Threshold
Chillers/heat pumps	> 70 kW (240,000 Btu/h) cooling capacity
Packaged AC units	> 70 kW (240,000 Btu/h) cooling
Fans	> 15 kW (20 hp)
Pumps	> 15 kW (20 hp)
Cooling towers	> 15 kW (20 hp)
Boilers and other heating equipment	> 300 kW (1,000,000 Btu/h) input

General lighting circuits

> 100 kVA

Miscellaneous electric loads

> 100 kVA

Meters shall be digital-type. Existing buildings are allowed to reuse installed existing analog-type utility company service/interval meters.

7.3.3.2 Meter Data Collection. All building meters shall be configured to communicate energy consumption data to a meter data management system. Meters shall provide data a minimum of daily and shall record a minimum of hourly consumption of energy.

7.3.3.3 Data Storage and Retrieval. The meter data management system shall be capable of electronically storing energy meter data and creating user reports showing calculated hourly, daily, monthly and annual energy consumption for each meter.

7.4 Prescriptive Option

7.4.1 General Comprehensive Prescriptive Requirements. When a requirement is provided below, it supersedes the requirement in ASHRAE/IESNA Standard 90.1. For all other criteria, the building project shall comply with the requirements of ASHRAE/IESNA Standard 90.1.

For multifamily residential building projects, the dwelling units shall be no larger than 90 m2 (900 ft2) for one-bedroom units, 125 m2 (1,250 ft2) for two-bedroom units, 170 m2 (1,700 ft2) for three-bedroom units and 210 m2 (2,100 ft2) for units with four or more bedrooms. Projects with larger dwelling units shall demonstrate compliance using 7.5.1.

7.4.2 Building Envelope. The building envelope shall comply with Section 5 of ASHRAE/IESNA Standard 90.1 with the following modifications and additions:

(a) Tables 5.5-1 to 5.5-8 of ASHRAE/IESNA Standard 90.1: The building envelope shall comply with the requirements Tables A-1 to A-8 in Normative Appendix A.

These requirements supersede the requirements in Tables 5.5-1 to 5.5-8 of ASHRAE/IESNA Standard 90.1.

Exception to 7.4.2(a): Buildings that comply with 8.3.7 regardless of building area are exempt from the SHGC criteria for skylights.

(b) Section 5.5.3.1 of ASHRAE/IESNA Standard 90.1: Roofs shall comply with the provisions of 5.3.2.3 and Tables A-1 to A-8 of this Standard. Section 5.5.3.1.1 of ASHRAE/IESNA Standard 90.1 and Table 5.5.3.1 of ASHRAE/IESNA Standard 90.1 shall not apply.

(c) Section 5.5.3.1, Section A2.4.2.4, and Table A2.4.2 of ASHRAE/IESNA Standard 90.1: Single-rafter roofs shall comply with the requirements in Table A-9 in Normative Appendix A. These requirements supersede the requirements in Section A2.4.2.4 of ASHRAE/IESNA Standard 90.1. Section A2.4.2.4 and Table A2.4.2 of ASHRAE/IESNA Standard 90.1 shall not apply.

(d) Section 5.5.4.2.1 of ASHRAE/IESNA Standard 90.1: The total vertical fenestration area shall be less than 40% of the gross wall area. This requirement supersedes the requirement in Section 5.5.4.2.1 of ASHRAE/IESNA Standard 90.1.

(e) Section 5.5.4.4 of ASHRAE/IESNA Standard 90.1: For climate zones 1-5, the vertical fenestration on the west, south, and east shall be shaded by permanent projections that have an area-weighted average projection factor of not less than 0.50 and that will last as long as the building itself. The building is allowed to be rotated up to 45 degrees to the nearest cardinal orientation for purposes of calculations and showing compliance.

(f) Section 5.5.4.4.1 of ASHRAE/IESNA Standard 90.1: For SHGC compliance, the methodology in exception (b) to Section 5.5.4.4.1 of ASHRAE/IESNA Standard 90.1 is allowed provided that the SHGC multipliers in Table 7.4.2 are used. This requirement supersedes the requirement in Table 5.5.4.4.1 of ASHRAE/IESNA Standard 90.1. Table 5.5.4.4.1 of ASHRAE/IESNA Standard 90.1 shall not apply.

Table 7.4.2 SHGC Multipliers

for Permanent Projections

Projection

SHGC
Multiplier

SHGC
Multiplier

Factor

(All Other
Orientations)

(North-
Oriented)

0-0.60

1.00

1.00

>0.60-0.70

0.92

0.96

>0.70-0.80

0.84

0.94

>0.80-0.90

0.77

0.93

>0.90-1.00

0.72

0.90

(g) Section 5.4.3.4 of ASHRAE/IESNA Standard 90.1: For vestibules, the exceptions to Section 5.4.3.4 of ASHRAE/IESNA Standard 90.1 are allowed provided that climate zone 4 is deleted from exception (e) to Section 5.4.3.4 of ASHRAE/IESNA Standard

90.1 and that climate zone 4 is added to exception (f) to Section 5.4.3.4 of ASHRAE/IESNA Standard 90.1.

(h) Section 5.6 of ASHRAE/IESNA Standard 90.1: The building envelope trade-off option in Section 5.6 of ASHRAE/IESNA Standard 90.1 shall not apply unless the procedure incorporates the modifications and additions to ASHRAE/IESNA Standard 90.1 noted above and below.

(i) In addition to ASHRAE/IESNA Standard 90.1, fenestration orientation: To reduce solar gains from the east and west in climate zones 1 through 4 and from the west in climate zones 5 and 6, the fenestration area and SHGC shall comply with the following requirements:

1. For climate zones 1, 2, 3, and 4:

(AN*SHGCN + AS*SHGCS) = 1.1*(AE*SHGCE + AW*SHGCW)

2. For climate zones 5 and 6:

1/3*(AN*SHGCN + AS*SHGCS + AE*SHGCE) = 1.1*(AW*SHGCW)

Where:

SHGCx = the SHGC for orientation x

Ax = fenestration area for orientation x

N = north (oriented less than 45 degrees of true north)

S = south (oriented less than 45 degrees of true south)

E = east (oriented less than or equal to 45 degrees of true east)

W = west (oriented less than or equal to 45 degrees of true west)

Exception to 7.4.2(i): Buildings adjacent to existing buildings on one or more sides.

(j) In addition to ASHRAE/IESNA Standard 90.1, continuous air barrier: The building envelope shall be designed and constructed with a continuous air barrier that complies with Normative Appendix B to control air leakage into, or out of, the conditioned space. All air barrier components of each envelope assembly shall be clearly identified on construction documents and the joints, interconnections and penetrations of the air barrier components shall be detailed.

Exception to 7.4.2 (j): Building envelopes of buildings in climate zones 1, 2, and 3; buildings over 7 stories above grade in all climate zones; or semiheated spaces in all climate zones provided the building envelope complies with Section 5.4.3.1 of ASHRAE/IESNA Standard 90.1.

7.4.3 Heating, Ventilating, and Air Conditioning. The heating, ventilating, and air conditioning shall comply with Section 6 of ASHRAE/IESNA Standard 90.1 with the following modifications and additions:

(a) Section 6.3.2 of ASHRAE/IESNA Standard 90.1: Criteria (c) of Section 6.3.2 of ASHRAE/IESNA Standard 90.1, which allows for the elimination of an airside economizer, is modified to require that for products with an IEER part load minimum requirement, that the IEER exceeds the minimum level defined in Appendix C by the percentage shown in Table 7.4.3-1. For products with only a full load minimum metric (EER or SEER), the full load efficiency shall exceed the minimum level defined in Appendix C by the percentage shown in Table 7.4.3-1.

Table 7.4.3-1 Minimum Efficiency Improvement
to Eliminate Airside Economizer

Zone	Minimum Efficiency Improvements
1a, 1b, 2a	0% (no economizer required)
2b	20%
3a	15%
3b	45%
3c	75%

4a

25%

4b

40%

4c

40%

5a

35%

5b

45%

5c

35%

6a

40%

6b

60%

7

60%

8

50%

(b) Sections 6.4.1.1 and 6.4.1.2 and Tables 6.8.1A to 6.8.1J of ASHRAE/IESNA

Standard 90.1: Projects shall comply with one of the following:

1. EPAct baseline. Products with minimum efficiencies addressed in the National Appliance Energy Conservation Act (NAECA) and Energy Policy Act (EPAct) provided that the building project contains:

i. on-site renewable energy power systems with twice the minimum capacity of that specified in 7.3.2, and

ii. peak load reduction systems with twice the peak load reduction specified in 7.4.5.

2. Higher Efficiency. For those products where there is an Energy Star program, the minimum efficiency shall be the greater of the Energy Star requirements in 7.4.7(c) or the values in Tables C-1 to C-15 in Normative Appendix C. For other

products, the equipment efficiency shall be a minimum of the values in Tables C-1 to C-15 in Normative Appendix C. These requirements supersede the requirements in Tables 6.8.1A to 6.8.1J of ASHRAE/IESNA Standard 90.1.

(c) Sections 6.4.3.4.1 and 6.4.3.4.2 of ASHRAE/IESNA Standard 90.1: Motorized dampers shall be installed for all applications. Exception a to Sections 6.4.3.4.1 and 6.4.3.4.2 of ASHRAE/IESNA Standard 90.1 shall not apply for outdoor intake dampers.

(d) Section 6.4.3.9 of ASHRAE/IESNA Standard 90.1: The threshold for controls to automatically reduce outdoor air intake below design rates when spaces are partially occupied shall be systems with design outdoor air capacities greater than 500 L/s (1000 cfm) serving areas having an average design occupancy density of 15 or more people per 100 m2 (1000 ft2). These requirements supersede the requirements in Section 6.4.3.9 of ASHRAE/IESNA Standard 90.1.

(e) Section 6.4.4.2 and Table 6.4.4.2A of ASHRAE/IESNA Standard 90.1: For duct sealing, Seal Level A shall be used. This requirement supersedes the requirements in Table 6.4.4.2A of ASHRAE/IESNA Standard 90.1.

(f) Section 6.5.1 and Table 6.5.1 of ASHRAE/IESNA Standard 90.1: Systems shall have economizers as specified in Table 7.4.3-2 and high-limit controls as specified in Table 7.4.3-3. Rooftop units with a capacity of less than 18 kW (60,000 Btu/h) shall have two stages of capacity control, with the first stage used for cooling with the economizer and the second stage to add mechanical cooling. These requirements supersede the requirements in Table 6.5.1 of ASHRAE/IESNA Standard 90.1. Exception (i) to Section 6.5.1 of ASHRAE/IESNA Standard 90.1 shall not apply.

Table 7.4.3-2 Minimum System Size for Which an

Economizer is Required

Climate Zones

Cooling Capacity for Which an
Economizer is Required

1A, 1B, 2A

No Economizer Requirement

2B, 3A, 3B, 3C, 4A, 4B, 4C,
5A, 5B, 5C, 6A, 6B, 7, 8

= 9.7 kW (33,000 Btu/h)a

a Where economizers are required, the total capacity of all systems without economizers shall not exceed 140 kW (480,000 Btu/h) per building or 20% of the building’s air economizer capacity, whichever is greater.

Table 7.4.3-3 High Limit Shutoff Control Options for Air Economizer

Climate Zones

Allowable Control Types

1A, 2A, 3A, 4A

Differential Enthalpya

1B, 2B, 3B, 3C, 4B, 4C,
5A, 5B, 5C, 6A, 6B, 7, 8

Differential Enthalpy or Differential
Drybulb

a Differential Enthalpy is that between the return air and the outside air.

Exceptions to 7.4.3 (f):

(a) For units with airside economizer, the economizer is allowed to be eliminated if: for products with an IEER part load minimum requirement, the product IEER rating exceeds the minimum level defined in appendix C by the percentage shown in the Table 7.4.3-1; or, for products with only a full load minimum metric (EER or SEER), the full load efficiency exceeds the minimum level defined in Appendix C by the percentage shown in the Table 7.4.3-1.

(b) For water-cooled units with a capacity less than 16 kW (54,000 Btu/h) that are used in systems where heating and cooling loads are transferred within the building (i.e. water source heat pump systems), the requirement for an air or water economizer can be eliminated if the condenser water temperature controls are capable of being set to maintain full load heat rejection capacity down to a 12 C (55 °F) condenser water supply temperature and the HVAC equipment is capable of operating with a 12 C (55 °F) condenser water supply temperature.

(g) Section 6.5.2.1 of ASHRAE/IESNA Standard 90.1: Exception (a) to Section 6.5.2.1 of ASHRAE/IESNA Standard 90.1 shall be replaced by the following: zones for which the volume of air that is reheated, recooled, or mixed is not greater than the larger of (i) the design minimum outdoor airflow rate for the zone, or (ii) 15% of the zone peak primary airflow rate. Exception (a) to Section 6.5.2.1 of ASHRAE/IESNA Standard 90.1 shall not apply.

(h) Section 6.5.3.1 and Table 6.5.3.1.1A of ASHRAE/IESNA Standard 90.1: Systems shall have fan power limitations 10% below limitations specified in Table 6.5.3.1.1A of ASHRAE/IESNA Standard 90.1. This requirement supersedes the requirement in Section 6.5.3.1 and Table 6.5.3.1.1A and of ASHRAE/IESNA Standard 90.1. All exceptions in Section 6.5.3.1 of ASHRAE/IESNA Standard 90.1 shall apply.

(i) Section 6.5.3.2.1 of ASHRAE/IESNA Standard 90.1: The following additional requirements shall apply:

1. DX systems with a capacity greater than 19 kW (65,000 Btu/h) shall have a minimum of 2 stages of cooling capacity.

2. where DX systems are used for constant-volume application, the indoor fans shall be equipped with a reduced-fan-speed option that will result in less than 40% power at 66% flow when operating in cooling. Controls shall be configured to use the reduced-speed-fan option when the unit mechanical cooling capacity is less than 65% or when the economizer is being used for cooling and the damper position is less than 90% open.

3. Units with a chilled-water cooling coil and a 3.8 kW (5 hp) or larger motor shall be equipped with a reduced fan speed option that will result in less than 30% power at 50% flow when the cooling load is less than 50%.

4. All DX and chilled-water VAV units shall be equipped with variable speed fans that result in less than 30% power at 50% flow.

(j) Section 6.5.4.1 of ASHRAE/IESNA Standard 90.1: Motors exceeding 15 kW (20 hp) shall have controls and/or devices (such as variable speed control) that will result in pump motor demand of no more than 30% of design wattage at 50% of design water flow. This requirement supersedes the requirements in Section 6.5.4.1 of ASHRAE/IESNA Standard 90.1.

(k) Section 6.5.6.1 of ASHRAE/IESNA Standard 90.1: The system shall comply with the energy recovery requirements in Table 7.4.3-3. Where a single room or space is supplied by multiple units, the aggregate supply L/s (cfm) of those units shall be used in applying this requirement.
Energy recovery systems shall have a minimum of 60% recovery effectiveness per Table 7.4.3-4. For equipment with airside economizers, provision shall be made for all outdoor and exhaust air to bypass the energy recovery device when not being used These requirements supersede the requirements in Section 6.5.6.1 of ASHRAE/IESNA Standard 90.1. All exceptions in 6.5.6.1 of ASHRAE/IESNA Standard 90.1 shall apply.

Table 7.4.3-4 Energy Recovery Requirement (SI)

Zone

% Outside Air at full design L/s

>10%
and
<
20%

>20
and
<30%

>30%
and
<
40%

>40%
and
<
50%

>50%
and
<
60%

>60%
and
<
70%

>70%
and
<
80%

>80%

Design Supply Fan L/s

2B,3B,3C,4B,4C,5B

NR

NR

NR

>7800

>4500

>2600

>2100

>1900

3A,4A

>5200

>3300

>2600

>2100

>1900

>1700

>900

>500

1A,2A, 5A, 6A, 6B

>2400

>2100

>1900

>1700

>1200

>700

>0

>0

7,8

>900

>0

>0

>0

>0

>0

>0

>0

Table 7.4.3-4 Energy Recovery Requirement (I-P)

Zone

% Outside Air at full design cfm

>10%
and
<
20%

>20
and
<30%

>30%
and
<
40%

>40%
and
< 50%

>50%
and
<
60%

>60%
and
<

70%

>70%
and
<
80%

>80%

Design Supply Fan CFM

2B,3B,3C,4B,4C,5B

NR

NR

NR

>16500

>9500

>5500

>4500

>4000

3A,4A

>11000

>7000

>5500

>4500

>4000

>3500

>2000

>1000

1A,2A, 5A, 6A, 6B

>5000

>4500

>4000

>3500

>2500

>1500

>0

>0

7,8

>2000

>0

>0

>0

>0

>0

>0

>0

Table 7.4.3-5 Performance Requirement for Energy Recovery Equipment (SI)

Equipment Type	Application	Rating Condition	Performance Required	Test Procedure
Energy Recovery	Cooling	35 C DB/25.6 C WB	= 60%Total Effectiveness	ARI 1060
Energy Recovery	Heating	1.7 C DB/0.6 C WB	= 60% Total Effectiveness	ARI 1060

Table 7.4.3-5 Performance Requirement for Energy Recovery Equipment (I-P)

Equipment Type	Application	Rating Condition	Performance Required	Test Procedure
Energy Recovery	Cooling	95°F DB/78°F WB	= 60%Total Effectiveness	ARI 1060
Energy Recovery	Heating	35°F DB/33°F WB	= 60% Total Effectiveness	ARI 1060

(l) Section 6.5.7.1 of ASHRAE/IESNA Standard 90.1, variable speed fan control for commercial kitchen hoods: In addition to the requirements in 6.5.7.1, commercial kitchen Type I and Type II hood systems shall have variable speed control for exhaust and make-up air fans to reduce hood airflow rates at least 50% during those times when the cooking equipment is under no-load conditions. These requirements supersede the requirements in Section 6.5.7.1 of ASHRAE/IESNA Standard 90.1. All exceptions in 6.5.7.1 of ASHRAE/IESNA Standard 90.1 shall apply.

(m) Section 6.8.2 and Tables 6.8.2A and Table 6.8.2B of ASHRAE/IESNA Standard 90.1: Duct insulation shall comply with the minimum requirements in Tables C-16 and C-17 in Normative Appendix C. These requirements supersede the requirements in Tables 6.8.2A and Table 6.8.2B of ASHRAE/IESNA Standard 90.1.

(n) Section 6.8.3 and Table 6.8.3 of ASHRAE/IESNA Standard 90.1: Pipe insulation shall comply with the minimum requirements in Table C-18 in Normative Appendix C. These requirements supersede the requirements in Table 6.8.3 of ASHRAE/IESNA Standard 90.1.

(o) In addition to ASHRAE/IESNA Standard 90.1, piping system pressure loss limitations: All copper and steel HVAC chilled water and condenser water piping systems shall be designed such that the fluid flow in L/s (gpm) in each pipe segment shall not exceed the values listed in Table 7.4.3-6 for the appropriate total annual hours of operation. Pipe size selections for systems that operate under variable flow conditions are allowed to be made from the "Variable Flow/ Constant Speed" column. Pipe size selections for systems that operate under variable flow conditions and that contain variable frequency drive pump motors are allowed to be made from the "Variable Flow/Variable Speed" columns. All others shall be made from the "Constant Flow/Constant Speed" columns.

Table 7.4.3-6: Piping System Design Maximum Flow Rate in L/S (SI)

<=2000 hours/yr

<=4400 hours/year

<=8760 hours/year

Pipe
Size
(mm)

Constant
Flow/
Constant
Speed

Variable
Flow/
Constant
Speed

Variable
Flow/
Variable
Speed

Constant
Flow/
Constant
Speed

Variable
Flow/
Constant
Speed

Variable

Flow/
Variable
Speed

Constant
Flow/
Constant
Speed

Variable
Flow/
Constant
Speed

Variable
Flow/
Variable
Speed

15

0.3

0.3

0.4

0.2

0.2

0.3

0.2

0.2

0.2

20

0.6

0.7

0.9

0.4

0.5

0.6

0.3

0.4

0.5

25

0.9

1.1

1.5

0.8

0.9

1.1

0.6

0.7

0.9

32

1.4

1.7

2.1

1.1

1.3

1.6

0.8

1

1.3

40

2.2

2.6

3.3

1.6

2

2.5

1.3

1.6

2

50

5

6

8

4

4

6

3

3

4

65

6

7

9

4

5

7

3

4

5

80

12

14

18

9

11

13

7

8

11

100

22

27

34

17

20

25

13

16

20

150

47

56

69

36

42

54

28

33

42

200

57

69

88

44

52

69

35

42

52

250

114

133

170

82

101

133

69

82

101

300

164

196

246

120

145

189

95

114

145

350

227

271

347

177

208

265

139

164

208

400

290

347

435

221

265

334

177

208

265

450

391

467

593

303

360

454

240

284

360

500

442

530

694

341

404

511

265

322

404

600

694

820

1010

517

612

757

410

486

612

700

883

1010

1262

631

757

1010

517

612

757

750

1136

1388

1704

883

1010

1325

694

820

1010

Table 7.4.3-6: Piping System Design Maximum Flow Rate in GPM (I-P)

<=2000 hours/yr

<=4400 hours/year

<=8760 hours/year

Pipe
Size (in)

Constant
Flow/
Constant
Speed

Variable
Flow/
Constant
Speed

Variable
Flow/
Variable
Speed

Constant
Flow/
Constant
Speed

Variable
Flow/
Constant
Speed

Variable
Flow/
Variable
Speed

Constant
Flow/
Constant
Speed

Variable
Flow/
Constant
Speed

Variable
Flow/
Variable
Speed

½

4

4.8

6.2

3

3.6

4.7

2.4

2.8

3.6

¾

8.9

11

14

6.7

8.1

10

5.3

6.3

8.1

1

15

18

23

12

14

18

9.2

11

14

1 ¼

22

27

34

17

20

26

13

16

20

1 ½

35

41

52

26

32

40

21

25

32

2

77

92

120

58

70

89

46

54

70

2 ½

88

110

140

67

80

110

52

63

80

3

190

220

280

140

170

210

110

130

170

4

350

420

540

270

320

400

210

250

320

5

410

490

640

320

380

480

250

300

380

6

740

880

1100

570

670

860

440

530

670

8

910

1100

1400

700

830

1100

550

660

830

10

1800

2100

2700

1300

1600

2100

1100

1300

1600

12

2600

3100

3900

1900

2300

3000

1500

1800

2300

14

3600

4300

5500

2800

3300

4200

2200

2600

3300

16

4600

5500

6900

3500

4200

5300

2800

3300

4200

18

6200

7400

9400

4800

5700

7200

3800

4500

5700

20

7000

8400

11000

5400

6400

8100

4200

5100

6400

24

11000

13000

16000

8200

9700

12000

6500

7700

9700

26

14000

16000

20000

10000

12000

16000

8200

9700

12000

30

18000

22000

27000

14000

16000

21000

11000

13000

16000

(p) In addition to ASHRAE/IESNA Standard 90.1, automatic control of HVAC and lights in hotel/motel guest rooms: A minimum of one of the following control technologies shall be required in hotel/motel guest rooms with over 50 guest rooms such that all the power to the lights and switched outlets in a hotel or motel guest room would be turned off when the occupant is not in the room and the space temperature would automatically setback (winter) or set up (summer) by no less than 3 C (5 ºF):

1. Controls that are activated by the room occupant via the primary room access method—key, card, deadbolt, etc.

2. Occupancy sensor controls that are activated by the occupant’s presence in the room.

7.4.4 Service Water Heating. The service water heating shall comply with Section 7 of ASHRAE/IESNA Standard 90.1 with the following modifications and additions:

(a) Section 7.4.2 and Table 7.8 of ASHRAE/IESNA Standard 90.1: Equipment shall comply with the minimum efficiencies in Table C-19 in Normative Appendix C. These requirements supersede the requirements in Table 7.8 of ASHRAE/IESNA Standard 90.1.

(b) Section 7.4.3 of ASHRAE/IESNA Standard 90.1: Pipe insulation shall comply with 7.4.3(k) above. These requirements supersede the requirements in Section 7.4.3 of ASHRAE/IESNA Standard 90.1.

(c) In addition to ASHRAE/IESNA Standard 90.1, insulation for spa pools: Pools heated to more than 32 C (90°F) shall have side and bottom surfaces insulated on the exterior with a minimum insulation value of R-2.1 (R-12).

7.4.5 Power. The power shall comply with Section 8 of ASHRAE/IESNA Standard 90.1 with the following modifications and additions:

(a) In addition to ASHRAE/IESNA Standard 90.1, transformer efficiency: Transformers shall comply with the minimum requirements in Table C-21 in Normative Appendix C.

(b) In addition to ASHRAE/IESNA Standard 90.1, load factor/peak load reduction: Building projects shall contain automatic systems such as demand-limiting or load shifting, not standby emergency power generation, to reduce peak capacity of the building by not less than 5.0% of the service overcurrent protection device rating for the building project.

7.4.6 Lighting. The lighting shall comply with Section 9 of ASHRAE/IESNA Standard 90.1 with the following modifications and additions:

(a) Sections 9.5 and 9.6 of ASHRAE/IESNA Standard 90.1: For all spaces except retail, the lighting power allowance shall be a maximum of 0.9 multiplied by the values determined in accordance with Sections 9.5 and 9.6. These requirements supersede the requirements in Sections 9.5 and 9.6 of ASHRAE/IESNA Standard 90.1.

(b) In addition to ASHRAE/IESNA Standard 90.1, occupancy sensor controls: Offices 25 m2 (250 ft2) or smaller, classrooms of any size, lecture, training, or vocational rooms of less than 100 m2 (1000 ft2), multipurpose rooms of less than 100 m2 (1000 ft2), and conference rooms and meeting rooms less than 100 m2 (1000 ft2) in hotels, convention, conference, multipurpose and meeting centers shall be equipped with occupant sensor(s) to shut off the lighting. In addition, controls shall be provided that allow manual shutoff of all lights. Occupancy sensors shall be either “manual ON” occupancy sensor or a bi-level “automatic ON” programmed to a low light level combined with multi-level circuitry and “manual ON” switching for higher light levels. Where such spaces are within a daylit area, occupancy sensors shall work in conjunction with daylighting controls complying with 7.4.6(e).

(c) In addition to ASHRAE/IESNA Standard 90.1, occupancy sensor controls with multi-level switching or dimming: The lighting in the following areas shall be controlled by an occupant sensor with multi-level switching or dimming system that reduces lighting power a minimum of 50% when no persons are present:

1. Hotel and motel hallways.

2. Commercial and industrial storage stack areas.

3. Library stack areas.

(d) In addition to ASHRAE/IESNA Standard 90.1, automatic controls for egress and security lighting: Lighting in any area within a building that is required to be continuously illuminated for reasons of building security or emergency egress shall not exceed 5 W/m2 (0.5 W/ft2). All other egress and security lighting shall be controlled by a time switch control device that turns off all lights.

(e) In addition to ASHRAE/IESNA Standard 90.1, automatic controls for lighting in daylight zones: Lighting in all daylight zones, both daylight zones under skylights and daylight zones adjacent to vertical fenestration, shall be provided with controls that automatically reduce lighting power in response to available daylight by either:

1. a combination of dimming ballasts and daylight-sensing automatic controls, which are capable of dimming the lights continuously, or

2. a combination of stepped switching and daylight-sensing automatic controls, which are capable of incrementally reducing the light level in steps automatically and turning the lights off automatically.

Exceptions to 7.4.6(e):

(a) Display, exhibition, and specialty lighting.

(b) Conference rooms greater than 25 m2 (250 ft2) that have a lighting control system with at least four scene options.

(f) In addition to ASHRAE/IESNA Standard 90.1, “manual ON” occupancy sensors: Occupancy sensors shall have “manual ON”, “automatic OFF” controls.

(g) In addition to ASHRAE/IESNA Standard 90.1, controls for outdoor lighting: For lighting of building facades, parking lots, garages, sales and non-sales canopies, and all outdoor sales areas, where two or more luminaires are used, an automatic time switch shall be installed that has the capability to turn off the lighting when not needed and reduces the lighting power (in watts) by a minimum of 50% but not exceeding 80% or provides continuous dimming through a range that includes 50% through 80% reduction.

Exceptions to 7.4.6(g):

(a) Lighting required by a health or life safety statute, ordinance, or regulation, including but not limited to, emergency lighting.

(b) Lighting for steps or stairs that require illumination during daylight hours.

(c) Lighting that is controlled by a motion sensor and photocontrol.

(d) Lighting for facilities that have equal lighting requirements at all hours and are designed to operate continuously.

(e) Temporary outdoor lighting.

(f) Internally illuminated, externally illuminated, and unfiltered signs.

7.4.7 Other Equipment. The other equipment shall comply with Section 10 of ASHRAE/IESNA Standard 90.1 with the following modifications and additions:

(a) Section 10.4.1 and Table 10.8 of ASHRAE/IESNA Standard 90.1: Motors shall comply with the minimum requirements in Table C-20 in Normative Appendix C. These requirements supersede the requirements in Section 10.4.1 and Table 10.8 of ASHRAE/IESNA Standard 90.1.

(b) In addition to ASHRAE/IESNA Standard 90.1, condenser heat recovery for space heating: Supermarkets 5,000 m2 (50,000 ft2) or greater shall have condenser waste heat recovery from freezers and coolers and shall use the waste heat for either for space heating, service water heating, or for dehumidification reheat for maintaining low space humidity.

(c) In addition to ASHRAE/IESNA Standard 90.1, Energy Star equipment: The following equipment within the scope of the applicable USEPA Energy Star program shall comply with the equivalent criteria required to achieve the Energy Star label:

1. appliances

i. battery chargers: Energy Star Program Requirements for Products with Battery Charger Systems (BCSs)

ii. clothes washers: Energy Star Program Requirements for Clothes Washers (see also the water efficiency requirements in 6.3.2.2)

iii. dehumidifiers: Energy Star Program Requirements for Dehumidifiers

iv. dishwashers: Energy Star Program Requirements for Dishwashers (see also the water efficiency requirements in 6.3.2.2)

v. refrigerators and freezers: Energy Star Program Requirements for Refrigerators and Freezers

vi. room air conditioners: Energy Star Program Requirements and Criteria for Room Air Conditioners (see also the energy efficiency requirements in 7.4.1)

vii. room air cleaners: Energy Star Program Requirements for Room Air Cleaners

viii. water coolers: Energy Star Program Requirements for Bottled Water Coolers

2. heating and cooling

i. residential air-source heat pumps: Energy Star Program Requirements for ASHPs and Central Air Conditioners (see also the energy efficiency requirements in 7.4.1)

ii. residential boilers: Energy Star Program Requirements for Boilers (see also the energy efficiency requirements in 7.4.1)

iii. residential central air conditioners: Energy Star Program Requirements for ASHPs and Central Air Conditioners (see also the energy efficiency requirements in 7.4.1)

iv. residential ceiling fans: Energy Star Program Requirements for Residential Ceiling Fans

v. dehumidifiers: Energy Star Program Requirements for Dehumidifiers

vi. ventilating fans: Energy Star Program Requirements for Residential Ventilating Fans

3. electronics

i. cordless phones: Energy Star Program Requirements for Telephony

ii. combination units (TV/VCR/DVD): Energy Star Program Requirements for TVs, VCRs, DCR TVs with POD Slots, Combination Units, Television Monitors, and Component Television Units

iii. DVD products: Energy Star Program Requirements for Consumer Audio and DVD

iv. audio: Energy Star Program Requirements for Consumer Audio and DVD

v. televisions: Energy Star Program Requirements for TVs, VCRs, DCR TVs with POD Slots, Combination Units, Television Monitors, and Component Television Units

vi. VCRs: Energy Star Program Requirements for TVs, VCRs, DCR TVs with POD Slots, Combination Units, Television Monitors, and Component Television Units

4. office equipment

i. computers: Energy Star Computer Memorandum of Understanding

ii. copiers: Energy Star Copier Memorandum of Understanding

iii. fax machines: Printer, Fax, Printer/Fax, and Mailing Machine Memorandum of Understanding

iv. laptops: Energy Star Computer Memorandum of Understanding

v. mailing machines: Printer, Fax, Printer/Fax, and Mailing Machine Memorandum of Understanding

vi. monitors: Energy Star Program Requirements for Computer Monitors

vii. multifunction devices (printer/fax/scanner): Energy Star Memorandum of Understanding for Multifunction Devices

viii. printers: Printer, Fax, Printer/Fax, and Mailing Machine Memorandum of Understanding

ix. scanners: Energy Star Scanner Memorandum of Understanding

5. lighting

i. compact fluorescent light bulbs (CFLs): Energy Star Program Requirements for CFLs

ii. residential light fixtures: Energy Star Program Requirements for Residential Light Fixtures

iii. residential ceiling fans: Energy Star Program Requirements for Residential Ceiling Fans

6. commercial food service

i. commercial fryers: Energy Star Program Requirements for Commercial Fryers

ii. commercial hot food holding cabinets: Energy Star Program Requirements for Hot Food Holding Cabinets

iii. commercial solid door refrigerators and freezers: Energy Star Program Requirements for Solid Door Refrigerators and Freezers

iv. commercial steam cookers: Energy Star Program Requirements for Commercial Steam Cookers (see also water efficiency requirements in 6.4.2.2)

v. commercial ice machines: Energy Star Program Requirements for Commercial Ice Machines

vi. commercial dishwashers: Energy Star Program Requirements for Commercial Dishwashers

7. other products

i. battery charging systems: Energy Star Program Requirements for Products with Battery Charger Systems (BCSs)

ii. external power adapters: Energy Star Program Requirements for Single-Voltage AC-DC and AC-AC Power Supplies

iii. traffic signals: Energy Star Program Requirements for Traffic Signals

iv. transformers: Energy Star Program Requirements for Commercial and Industrial Transformers (see also the energy efficiency requirements in 7.4.5)

v. vending machines: Energy Star Program Requirements for Refrigerated Beverage Vending Machines

Exceptions to 7.4.7(c): Products with minimum efficiencies addressed in the USGPO Energy Policy Act (EPAct).

(d) In addition to ASHRAE/IESNA Standard 90.1, commercial refrigerators, freezers, and clothes washers:

1. Commercial refrigerators and freezers shall comply with the minimum efficiencies in Table C-22 in Normative Appendix C. Open refrigerated display cases are prohibited. Lighting loads, including all power supplies or ballasts, for commercial reach-in refrigerator/freezer display cases shall not exceed 42 watts per door for case doors up to 1.5 m (5 ft) in height and 46 watts per door for case doors greater than 1.5 m (5 ft) in height.

2. Commercial clothes washers shall comply with the minimum efficiencies in Table C-23 in Normative Appendix C.

7.4.8 Energy Cost Budget. The Energy Cost Budget option in Chapter 11 of ASHRAE/IESNA Standard 90.1 shall not be used.

7.5 Performance Option

7.5.1 General Comprehensive Performance Requirements. Projects shall comply with 7.5.2, 7.5.3, and 7.5.4.

The baseline for a multifamily residential building shall be a building with the same number of dwelling units. Each dwelling unit in the building shall be the smaller of:

(a) a baseline dwelling unit of the same size as in the proposed building, or

(b) a baseline dwelling unit no larger than 90 m2 (900 ft2) for one-bedroom units, 125 m2
(1,250 ft2) for two-bedroom units, 170 m2 (1,700 ft2) for three-bedroom units and 210 m2 (2,100 ft2) for units with four or more bedrooms.

7.5.2 Annual Energy Cost. The building project shall have an annual energy cost less than or equal to that achieved by compliance with 7.3 and 7.4, and 5.3.2.2, 5.3.2.3, 6.3.2, 6.4.2, 8.3.1, 8.3.7, and 8.4.1. Comparisons shall be made using Normative Appendix D provided that the baseline building design is calculated in accordance with the modifications and additions in Sections 7.3.1 through 7.3.3 and 7.4.1 through 7.4.7, and 5.3.2.2, 5.3.2.3, 6.3.2, 6.4.2, 8.3.1, 8.3.7, and 8.4.1.

Exceptions to 7.5.2: Credit for daylighting controls is allowed to be taken up to a distance of 2.5 x window head height where all lighting more than 4.5 m (15 ft) from the perimeter is automatically controlled separately from lighting within 4.5 m (15 ft) of the perimeter.

7.5.3 Annual Carbon Dioxide Equivalent (CO2e). The building project shall have an annual CO_2e less than or equal to that achieved by compliance with 7.3 and 7.4, and 5.3.2.2, 5.3.2.3, 6.3.2, 6.4.2, 8.3.1, 8.3.7, and 8.4.1. Comparisons shall be made using Normative Appendix D provided that the baseline building design is calculated in accordance with the modifications and additions in Sections 7.3.1 through 7.3.3 and 7.4.1 through 7.4.7, and 5.3.2.2, 5.3.2.3, 6.3.2, 6.4.2, 8.3.1, 8.3.7, and 8.4.1. To determine the CO_2e value for each energy source supplied to the building project, multiply the energy consumption by the emissions factor. CO_2e emission factors shall be taken from Table 7.5.3.

Table 7.5.3: CO2e Emission Factors

Building Project Energy Source	CO2e kg/kWh (lb/kWh)
Grid delivered electricity and other fuels not specified in this table	0.758 (1.670)
LPG or propane	0.274 (0.602)
Fuel oil (residual)	0.312 (0.686)
Fuel oil (distillate)	0.279 (0.614)
Coal (except lignite)	0.373 (0.822)
Coal (lignite)	0.583 (1.287)
Gasoline	0.309 (0.681)
Natural gas	

0.232 (0.510)

7.5.4 Load Factor/Peak Electric Demand. The building project shall have the same or less peak electric demand than achieved by compliance with 7.3 and 7.4, and 5.3.2.2, 5.3.2.3, 6.3.2, 6.4.2, 8.3.1, 8.3.7, and 8.4.1. Comparisons shall be made using Normative Appendix D provided that the baseline building design is calculated in accordance with the modifications and additions in Sections 7.3.1 through 7.3.3 and 7.4.1 through 7.4.7, and 5.3.2.2, 5.3.2.3, 6.3.2, 6.4.2, 8.3.1, 8.3.7, and 8.4.1. In addition, the building project shall have a minimum electrical load factor of 0.25.

8. INDOOR ENVIRONMENTAL QUALITY (IEQ)

8.1 Scope. This section specifies requirements for indoor environmental quality including indoor air quality, environmental tobacco smoke control, outdoor air delivery monitoring, thermal comfort, building entrances, acoustic control, daylighting, and low emitting materials.

8.2 Compliance. The indoor environmental quality shall comply with 8.3, Mandatory Provisions; and either

(a) 8.4, Prescriptive Option, or

(b) 8.5, Performance Option.

Daylighting and low-emitting materials are not required to use the same option, i.e. Prescriptive or Performance, for demonstrating compliance.

8.3 Mandatory Provisions

8.3.1 Minimum Indoor Air Quality. The building shall comply with Sections 4-7 of ASHRAE Standard 62.1 with the following modifications and additions. When a requirement is provided below, this supersedes the requirements in ASHRAE Standard 62.1.

(a) Section 5.9 of ASHRAE Standard 62.1: The particulate matter filters or air cleaners shall have a MERV of not less than 8 and shall comply with and be provided where required in Section 5.9 of ASHRAE Standard 62.1.

(b) Section 6.2.2 of ASHRAE Standard 62.1: The zone-level design minimum outdoor airflow rates in all occupiable spaces except office spaces and classrooms shall be greater than or equal to the airflow calculated using the Ventilation Rate Procedure in Section 6.2 of ASHRAE Standard 62.1.

(c) Section 6.2.2 of ASHRAE Standard 62.1: The zone-level design minimum outdoor airflow rates in all occupiable spaces that are in office spaces and in classrooms shall be greater than or equal to 1.3 times the airflow calculated using the Ventilation Rate Procedure in Section 6.2 of ASHRAE Standard 62.1.

Exception to 8.3.1(c): The following shall have a zone-level design minimum outdoor airflow rate that is greater than or equal to the airflow calculated using the Ventilation Rate Procedure in Section 6.2 of ASHRAE Standard 62.1:

1. Office spaces and classrooms in climate zones 1A and 2A.

2. Office spaces in climate zones 6, 7, and 8 that are not required by Section 7.4.3(k) to have heat recovery systems.

3. Office spaces and classrooms located in an area that is in “non-attainment” with the National Ambient Air Quality Standards for sulfur dioxide, carbon monoxide, nitrogen dioxide, ozone, or lead as determined in Section 4 of ASHRAE Standard 62.1.

4. Office spaces and classrooms designed according to the IAQ Procedure using only Design Approach (a) (mass balance analysis) in Section 6.3.1.4 of ASHRAE Standard 62.1, provided that the predicted contaminant concentration for each contaminant of concern in each zone is equal to or less than the concentration expected when using the design minimum outdoor airflow rate calculated in accordance with 8.3.1(c). (Paragraph 8.3.1 (b) shall still be complied with.)

(d) Section 6.2 of ASHRAE Standard 62.1: The system-level design minimum outdoor airflow rate calculation shall be based on the zone-level design minimum outdoor airflow rates calculated in 8.3.1 (b) and (c).

(e) Section 6.2.1.1 of ASHRAE Standard 62.1: In addition to Section 6.2.1.1, when the building is located in an area that is in “non-attainment” with the National Ambient Air Quality Standards for PM2.5 as determined in Section 4 of ASHRAE Standard 62.1, particle filters or air-cleaning devices having a MERV of not less than 13 when rated in accordance with ASHRAE Standard 52.2 shall be provided to clean outdoor air at any location prior to its introduction to occupied spaces. Filter frames, filter racks, access doors, and filter cartridges shall be sealed to eliminate air bypass pathways.

(f) Section 6.2.9 of ASHRAE Standard 62.1: Section 6.2.9 of ASHRAE Standard 62.1 is superseded by 8.3.2.

8.3.2 Environmental Tobacco Smoke Control

(a) Smoking shall not be allowed inside the building. Signage stating such shall be posted within 3 m (10 ft) of each building entrance.

(b) Any exterior designated smoking areas shall be located a minimum of 7.5 m (25 ft) away from building entrances, outdoor air intakes, and operable windows.

8.3.3 Outdoor Air Delivery Monitoring

8.3.3.1 Spaces Ventilated by Mechanical Systems.

(a) For each densely occupied space, a permanently installed carbon dioxide CO_2 monitoring system shall be provided that records ventilation system performance in terms of differential indoor-to-outdoor CO_2 levels. CO_2 sensors or air sampling probes shall be located in the room between 1 m and 2 m (3 ft and 6 ft) above the floor. The CO_2 monitoring system shall be capable of indicating the CO_2 level in a direct read-out display in the occupied space, conveying such level to a building central monitoring system, or both. The CO_2 sensors shall be capable of an accuracy level of ± 50 ppm.

Outdoor air CO_2 concentrations shall be determined by one of the following:

1. CO_2 concentration shall be assumed to be 400 ppmv without any direct measurement; or

2. CO_2 concentration shall be dynamically measured using a CO_2 sensor located near the position of the outdoor air intake.

(b) For each mechanical ventilation system serving only non-densely occupied spaces, a permanently mounted, direct total outdoor airflow measurement device shall be provided that is capable of measuring the design minimum outdoor airflow rate, as defined by 8.3.1. The device shall be capable of measuring flow within an accuracy of ±15% of the minimum outdoor airflow rate. The device shall also be capable of signaling an alarm to the building operator and initiating return to required levels.

(c) For each mechanical ventilation system serving a combination of densely occupied spaces and non-densely occupied spaces, a direct total outdoor airflow measurement device shall be provided that is capable of measuring the design minimum outdoor airflow rate, as defined by 8.3.1. The device shall be capable of measuring flow within an accuracy of ±15% of the minimum outdoor airflow rate. The device shall also be capable of signaling an alarm to the building operator and initiating return to required levels. In addition, each densely occupied space in such as system shall have CO2 monitoring complying with the requirements specified in 8.3.3.1(a).

8.3.3.2 Naturally Ventilated Spaces. A permanently-installed CO2 monitoring system shall be provided in occupiable spaces without a mechanical ventilation system. Indoor CO2 sensors or air sampling probes shall be located within the room between 1 m and 2 m (3 ft and 6 ft) above the floor and on a wall location at least 6 m (20 ft) from operable openings. The CO2 monitoring system shall be capable of indicating the CO2 level in a direct read-out display in the occupied space, conveying such level to a building central monitoring system, or both. The CO2 sensors shall be capable of an accuracy level of ± 50 ppm. Where floor plans are less than 12 m (40 ft) wide, sensors shall be located as close to center of space as practical. One CO2 sensor is allowed to be used to represent multiple spaces if the natural ventilation design uses passive stack(s) or other means to induce airflow through those spaces equally and simultaneously without intervention by building occupants.

8.3.4 Thermal Comfort. The building shall be designed to provide indoor conditions that comply with the comfort requirements of ASHRAE Standard 55.

8.3.5 Building Entrances. All building entrances shall employ an entry mat system that shall have a scraper surface, an absorption surface, and a finishing surface. Each surface shall be a minimum of the width of the entry opening, and the minimum length is measured in the primary direction of travel.

8.3.5.1 Scraper Surface. The scraper surface shall comply with the following:

(a) shall be the first surface stepped on when entering the building.

(b) shall be either immediately outside or inside the entry.

(c) shall be a minimum of 1 m (3 ft) long.

(d) shall be either permanently mounted grates or removable mats with knobby or squeegee-like projections.

8.3.5.2 Absorption Surface. The absorption surface shall comply with the following:

(a) shall be the second surface stepped on when entering the building.

(b) shall be a minimum of 1 m (3 ft) long, and generally made from nylon or combinations of nylon and heavily textured piles of polypropylene that can perform both a scraping action and a moisture wicking action.

8.3.5.3 Finishing Surface. The finishing surface shall comply with the following:

(a) shall be the third surface stepped on when entering the building.

(b) shall be a minimum of 1.2 m (4 ft) long, and generally made from polypropylene with a course fiber surface that will both capture and hold any remaining particles or moisture.

Exception to 8.3.5: Length of entry mat surfaces is allowed to be reduced due to a barrier, such as a counter, partition, or wall, or local regulations prohibiting the use of scraper surfaces outside the entry. In this case entry mat surfaces shall have a minimum length of 1 m (3 ft) of indoor surface, with a minimum combined length of 2 m (6 ft).

8.3.6 Acoustical Control.

8.3.6.1 Exterior Sound. Wall and roof-ceiling assemblies that are part of the building envelope shall have a composite outdoor-indoor transmission class (OITC) rating of 40 or greater or a composite sound transmission class (STC) rating of 50 or greater, and fenestration that is part of the building envelope shall have an OITC or STC rating of 30 or greater for any of the following conditions:

(a) Buildings within 300 m (1000 ft) of expressways.

(b) Buildings within 8 km (5 mi) of airports serving more than 10,000 commercial jets per year.

(c) Where yearly average day-night average sound levels at the property line exceed 65 decibels.

8.3.6.2 Interior Sound. Interior wall and floor/ceiling assemblies separating interior rooms and spaces shall be designed in accordance with all of the following:

(a) Wall and floor-ceiling assemblies separating adjacent dwelling units, dwelling units and public spaces, adjacent tenant spaces, tenant spaces and public places, and adjacent classrooms shall have a composite STC rating of 50 or greater.

(b) Wall and floor-ceiling assemblies separating hotel rooms, motel rooms, and patient rooms in nursing homes and hospitals shall have a composite STC rating of 45 or greater.

(c) Wall and floor-ceiling assemblies separating classrooms from rest rooms and showers shall have a composite STC rating of 53 or greater.

(d) Wall and floor-ceiling assemblies separating classrooms from music rooms, mechanical rooms, cafeteria, gymnasiums, and indoor swimming pools shall have a composite STC rating of 60 or greater.

8.3.6.3 Outdoor-Indoor Transmission Class and Sound Transmission Class.
OITC values for assemblies and components shall be determined in accordance with

ASTM E1332. STC values for assemblies and components shall be determined in accordance with ASTM E90 and ASTM E413.

8.3.7 Daylighting by Toplighting. There shall be a minimum fenestration area providing daylighting by toplighting for large enclosed spaces. In buildings three stories and less above grade, conditioned or unconditioned enclosed spaces that are greater than 2,000 m2 (20,000 ft2) directly under a roof with a finished ceiling heights greater than 3.5
m (12 ft) and that have a lighting power density (LPD) for general lighting equal to or greater than 5.5 W/m2 (0.5 W/ft2) shall comply with the following:

Exceptions to 8.3.7:

(a) Buildings in climate zones 7 and 8.

(b) Auditoria, theaters, museums, places of worship, and refrigerated warehouses.

(a) Minimum Daylight Zone by Toplighting. A minimum of 50% of the floor area directly under a roof shall be in the daylight zone. Areas that are daylit shall have a minimum toplighting area to daylight zone area ratio as shown in Table 8.3.7.

Table 8.3.7 Minimum Toplighting Area

General Lighting Power Density in Daylight ZoneW/m2 (W/ft2)

Minimum Toplighting
Area to Daylight Zone
Area Ratio

14 W/m2 (1.4 W/ft2) < LPD

3.6%

10 W/m2 (1.0 W/ft2) < LPD < 14 W/m2 (1.4 W/ft2)

3.3%

5 W/m2 (0.5 W/ft2) < LPD < 10 W/m2 (1.0 W/ft2)

3.0%

(b) Skylight Characteristics. Skylights shall have a glazing material or diffuser that has a measured haze value greater than 90%, tested according to ASTM D1003 (notwithstanding its scope) or other test method approved by the authority having jurisdiction.

Exceptions to 8.3.7(b):

(a) Tubular daylighting devices having a diffuser.

(b) Roof monitors and clerestories having one or more of the following that prevent direct sunlight from entering the space below the well:

1. automated shading devices.

2. a diffuser.

3. fixed internal baffles.

8.4 Prescriptive Option

8.4.1 Daylighting by Sidelighting.

8.4.1.1 Minimum Effective Aperture. Office spaces and classrooms shall comply with the following criteria:

(a) All north-, south-, and east-facing facades for those spaces shall have a minimum effective aperture for vertical fenestration (EAvf) as prescribed in Table 8.4.1.1.

(b) Interior surfaces in daylight zones shall have visible light reflectances greater than or equal to 80% for ceilings and 70% for partitions higher than 1.5 m (60 in.) in daylight zones.

Table 8.4.1.1 Minimum Effective Aperture for Sidelighting by Vertical Fenestration

Climate Zone	Minimum Effective Aperture for Sidelighting by Vertical Fenestration
1, 2, 3A, 3B	0.10
3C, 4, 5, 6, 7, 8	0.15

Exceptions to 8.4.1.1:

(a) Spaces with programming that requires dark conditions (e.g. photographic processing centers, museums).

(b) Spaces required to have toplighting under 8.3.7.

(c) Facades that are less than 3 m (10 ft) from an adjacent building. (For a space with multiple facades, those portions of other facades that do not qualify under this exception shall comply with 8.4.1.1.)

8.4.1.2 Office Space Shading. Each west-, south-, and east-facing façade, shall have a shading projection factor no less than that specified in 7.4.2(e). Shading is allowed to be external or internal. The building is allowed to be rotated up to 45 degrees for purposes of calculations and showing compliance. The following shading devices are allowed to be used:

(a) Louvers, sun shades, light shelves, and any other permanent device. Any vertical fenestration that employs a combination of interior and external shading is allowed to be separated into multiple segments for compliance purposes. Each segment shall comply with the requirements for either external or interior projection factor.

(b) Building self-shading through roof overhangs or recessed windows.

(c) External buildings and other permanent infrastructure or geological formations that are not part of the building. Trees, shrubs, or any other organic shading device shall not be used to comply with the shading projection factor requirements.

Exception to 8.4.1.2:

(a) Building projects that comply with the prescriptive compliance option in 7.4.2.

(b) Translucent panels and glazing systems with a measured haze value greater than 90%, tested according to ASTM D1003 (notwithstanding its scope) or other test method approved by the authority having jurisdiction do not require external shading devices.

8.4.2 Low Emitting Materials

8.4.2.1 Adhesives and Sealants. All adhesives and sealants used on the interior of the building (defined as inside of the weatherproofing system and applied on-site) shall comply with the requirements of the following reference standards:

(a) Adhesives, Sealants and Sealant Primers: VOC content shall be determined according to and comply with the limit requirements of SCAQMD Rule 1168.

(b) Aerosol Adhesives: VOC content shall be determined according to and comply with the limit requirements of Green Seal Standard GS-36.

8.4.2.2 Paints and Coatings. Paints and coatings used on the interior of the building (defined as inside of the weatherproofing system and applied on-site) shall comply with the following criteria:

(a) Architectural paints, coatings and primers applied to interior walls and ceilings: VOC content shall be determined according to and comply with the limit requirements of Green Seal Standard GS-11.

(b) Clear wood finishes, floor coatings, stains, sealers, and shellacs: VOC content shall be determined according to and comply with the limit requirements of SCAQMD Rule 1113.

8.4.2.3 Floor Covering Materials. Floor covering materials installed in the building interior shall comply with the following :

(a) Carpet: Carpet shall be tested in accordance with and shown to be compliant with the requirements of CA/DHS/EHLB/R-174 (commonly referred to as CDHS California Section 01350). Products that have been verified and labeled to be in compliance with CA/DHS/EHLB/R-174 comply with this requirement.

(b) Hard surface flooring in office spaces and classrooms: Materials shall be tested in accordance with and shown to be compliant with the requirements of SCS-EC10.2. Products that have been verified and labeled to be in compliance with SCS-EC10.2 by a third-party certifier comply with this requirement.

8.4.2.4 Composite Wood, Plywood and Agrifiber Products. Composite wood, plywood and agrifiber products used on the interior of the building (defined as inside of the weatherproofing system) shall contain no added urea-formaldehyde resins. Laminating adhesives used to fabricate on-site and shop-applied composite wood and agrifiber assemblies shall contain no added urea-formaldehyde resins. Composite wood and agrifiber products are defined as: particleboard, medium density fiberboard (MDF), wheatboard, strawboard, panel substrates and door cores. Materials considered fit-out, furniture, and equipment (FF&E) are not considered base building elements and are not included.

Exception to 8.4.2.4: Structural panel components such as plywood, particle board, wafer board, and oriented strand board identified as "EXPOSURE 1", "EXTERIOR" or "HUD-APPROVED" are considered acceptable for interior use.

8.5 Performance Option

8.5.1 Daylighting Simulation.

8.5.1.1 Usable Illuminance in Office Spaces and Classrooms. The design for the building project shall demonstrate a useable illuminance of 300 lux (30 fc) on all work surfaces at a distance of 4.5 m (15 ft) from the façade at noon on the equinox using an accurate physical or computer daylighting model that includes all regularly occupied daylit spaces.

(a) Computer models shall be built using daylight simulation software based on the ray-tracing or radiosity methodology.

(b) Simulation is to be done using either the CIE Overcast Sky Model or the CIE Clear Sky Model and measurements shall be taken at noon on the equinox.

(c) Simulation shall measure illuminance at points 0.75 m (30 in.) above the floor on a 3 m by 3 m (10 ft by 10 ft) grid. Every modeled point within a space shall achieve the minimum illuminance.

(d) Achievement of minimum illuminance levels shall not include measurement points on which there is a direct beam solar component that is incident on the measured plane. If an advanced daylighting system is used to harness and redirect direct solar radiation, then direct beam solar component is allowed to be included in the simulation, as long as it is not used to comply with the minimum illuminance through direct incidence on the measured plane.

(e) Scheduling used to determine regularly occupied spaces shall be consistent with energy calculation scheduling. A space that is scheduled to be used more than 4 hours per day constitutes a regularly occupied space.

8.5.1.2 Direct Sun Limitation on Workplane in Offices. It shall be demonstrated that direct sun does not strike the workplane in any daylit space for more than 20% of the occupied hours during an equinox day in regularly occupied office spaces.

8.5.2 Low Emitting Materials. Spaces within the building shall be modeled for VOC concentration and shall be shown to be in compliance with CA/DHS/EHLB/R-174. Modeling shall use standardized building scenarios. Spaces other than classrooms shall use the office space scenario. Materials used on the interior of the building (defined as inside of the weatherproofing system and applied on-site) shall be tested in accordance with the requirements of CA/DHS/EHLB/R-174. All of the following products shall be tested in whole or by representative sample in small-scale environmental chambers:

(a) Tile, strip, panel and plank products including vinyl composition tile, resilient floor tile, linoleum tile, wood floor strips, parquet flooring, laminated flooring, and modular carpet tile.

(b) Sheet and roll goods including broadloom carpet, sheet vinyl, sheet linoleum, carpet cushion, wallcovering, and other fabric.

(c) Rigid panel products including gypsum board, other wall paneling, insulation board, oriented strand board, medium density fiber board, plywood, acoustical ceiling tiles, and particleboard.

(d) Insulation batt products.

(e) Containerized products including adhesives, sealants, paints, other coatings, primers and other "wet" products.

(f) Cabinets, shelves, and worksurfaces that are permanently attached to the building before occupancy.

Exception to 8.5.2: Salvaged materials that have not been refurbished or refinished within one year prior to installation are excepted from this requirement.

9. THE BUILDING'S IMPACT ON THE ATMOSPHERE, MATERIALS AND RESOURCES

9.1 Scope. This section specifies requirements for the building's impact on the atmosphere, materials, and resources including construction waste management, refrigerants, storage and collection of recyclables, and reduced impact materials.

9.2 Compliance. The building materials shall comply with 9.3, Mandatory Provisions; and either

(a) 9.4, Prescriptive Option, or

(b) 9.5, Performance Option.

9.3 Mandatory Provisions

9.3.1 Construction Waste Management. A minimum of 50% of non-hazardous construction and demolition waste material shall be diverted from disposal in landfills and incinerators by recycling and/or reuse. Reuse includes donation of materials to charitable organizations and salvage of existing materials on-site. Excavated soil and land-clearing debris shall not be included in the calculation. Calculations are allowed to be done by either weight or volume, but shall be consistent throughout. Specific area(s) on the construction site shall be designated for collection of recyclable and reusable materials. Diversion efforts shall be tracked throughout the construction process.

9.3.2 Wood Products. Wood products in the project, other than recovered or reused wood:

(a) shall be harvested according to the laws and regulations of the country of origin.

(b) shall not contain wood from endangered wood species, unless their trade conforms with the requirements of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

9.3.3 Refrigerants. CFC-based refrigerants in HVAC&R systems shall not be used. The HVAC&R equipment shall comply with the following formula, which sets a maximum threshold for the combined contributions to ozone depletion and global warming potential:

LCGWP + LCODP x 105 = 775 (100)

where:

$$LCGWP = [GWPr \times (Lr \times Life + Mr) \times Rc]/Life$$

$$LCODP = [ODPr \times (Lr \times Life + Mr) \times Rc]/Life$$

LCGWP = Lifecycle Direct Global Warming Potential, kg CFC11/kw-yr (lb CO_2/ton-yr)

LCODP = Lifecycle Ozone Depletion Potential, kg CFC11/kw-yr (lb CFC11/ton-yr)

GWPr = Global Warming Potential of Refrigerant, 0 to 12,000 kg CO_2/kg r (lb CO_2/lb r)

ODPr = Ozone Deletion Potential of Refrigerant, 0 to 0.2 kg CO2/kg r (lb CFC11/lb r)

Lr = Refrigerant Leakage Rate, 0.5% to 2.0%; default of 2% unless otherwise demonstrated

Mr = End-of-life Refrigerant Loss, 2% to 10%; default of 10% unless otherwise demonstrated

Rc = Refrigerant Charge, 0.2 to 2.3 kg (0.5 to 5.0 lbs) of refrigerant per ton of cooling capacity

Life = Equipment Life, 10 years; default based on equipment type, unless otherwise demonstrated

For multiple types of equipment, a weighted average of all HVAC&R equipment shall be applied using the following formula:

[S (LCGWP + LCODP x 105) x Qunit] / Qtotal = 775 (100)

where:

Qunit = Cooling capacity of an individual HVAC or refrigeration unit, kW (tons)

Qtotal = Total cooling capacity of all HVAC or refrigeration

Exception to 9.3.3: Small HVAC units (defined as containing less than 0.23 kg (0.5 lb) of refrigerant), and other equipment such as standard refrigerators, small water coolers, and any other cooling equipment that contains less than 0.23 kg (0.5 lb) of refrigerant.

Fire suppression systems shall not contain ozone-depleting substances (CFCs, HCFCs or Halons).

9.3.4 Storage and Collection of Recyclables and Discarded Goods.

9.3.4.1 Recyclables. There shall be an area that serves the entire building and is dedicated to the collection and storage of non-hazardous materials for recycling, including paper, corrugated cardboard, glass, plastics and metals. The size and functionality of the recycling areas shall be coordinated with the anticipated collection services for glass, plastic, office paper, newspaper, cardboard and organic wastes to maximize the effectiveness of the dedicated areas.

9.3.4.2 Reusable goods. For building projects with residential spaces, there shall be an area that serves the entire building and is dedicated to the collection and storage of discarded but clean items in good condition. Charitable organizations or others to arrange for periodic pick-ups shall be identified and posted.

9.3.4.3 Fluorescent and HID Lamps and Ballasts. An area shall be provided that serves the entire building and is dedicated to collection and storage of fluorescent and HID lamps and ballasts and facilitates proper disposal and/or recycling according to state and local hazardous waste requirements.

9.4 Prescriptive Option

9.4.1 Reduced Impact Materials. The building project shall contain materials that comply with 9.4.1.1, 9.4.1.2, or 9.4.1.3. Components of mechanical, electrical, and plumbing systems, and elevators and equipment shall not be included in the calculations. Calculations shall only include materials permanently installed in the project. A value of 45% of the total construction cost is allowed to be used in lieu of the actual total cost of materials.

9.4.1.1 Recycled Content. The sum of post-consumer recycled content plus one-half of the pre-consumer recycled content shall constitute a minimum of 10%, based on cost, of the total materials in the building project. The recycled content value of a material assembly shall be determined by weight. The recycled fraction of the assembly shall then be multiplied by the cost of assembly to determine the recycled content value. Not more than 5% (one-half of the 10%) of the recycled content for this requirement shall come from one type of material such as steel or concrete.

The annual average industry values for the recycled content of steel products manufactured in basic oxygen furnaces and electric arc furnaces are allowed to be used as the recycled content of the steel. The recycled content of the supplementary cementitious materials (e.g. fly ash, slag cement, or silica fume) in concrete is allowed to be used as the recycled content of the concrete when the total amount of cementitious materials in the actual mix design is not increased compared to a baseline 28-day strength mix design using only Portland cement and complying with the same specified performance requirements.

9.4.1.2 Regionally Extracted/Harvested/Recovered and Manufactured Materials. A minimum of 15% of building materials or products used, based on cost, shall be regionally extracted/harvested/recovered and manufactured. For a building material or product to qualify, a minimum of 80% of the mass of the building material or product shall be extracted/harvested/recovered and manufactured within a radius of 800 km (500 mi) of the project site.

Exception to 9.4.1.2: For building materials or products shipped in part by rail or water, that portion of the distance shipped by rail or water shall be multiplied by 0.25 and added to that portion not shipped by rail or water, provided that the total does not exceed 800 km (500 mi).

9.4.1.3 Biobased Products. A minimum of 5% of building materials used, based on cost, shall be biobased products. Biobased products shall comply with the minimum biobased contents of the USDA's Designation of Biobased Items for Federal Procurement, contain the “USDA Certified Biobased Product” label, or be composed of solid wood, engineered wood, bamboo, wool, cotton, cork, agricultural fibers, or other biobased materials with at least 50% biobased content.

Wood building components used to comply with this requirement shall be from sources proven legal and which practice sustainable (environmentally preferable) forest management as verified through accredited, independent, third-party certification bodies. Chain of custody documentation is required and shall verify that certified components contain a minimum of 70% certified raw material. Acceptable forest management certification bodies are those with principles, criteria, and standards developed using ISO/IEC Guide 59 Code of Good Practice for Standardization, or the World Trade Organization (WTO) Technical Barriers to Trade (TBT) Agreement Annex 3 Code of Good Practice for the Preparation, Adoption and Application of Standards. Wood building components include, but are not limited to, structural framing and general dimensional framing, flooring, sub-flooring, wood window sash and frames, solid wood doors, and architectural millwork. Wood building components from a vendor are allowed to comply when the annual average amount of certified wood products purchased by the vendor, for which they have chain of custody verification not older than two years, is 70% or greater of their total annual wood products purchased.

9.5 Performance Option

9.5.1 Life Cycle Assessment. Perform a life cycle assessment (LCA) according to ISO Standard 14044 of a minimum of two building alternatives, both of which shall conform to the owner's project requirements. Each building alternate shall consist of a common design, construction, and materials for the locale, including building size and use, as commonly approved by the authority having jurisdiction. Each building alternate shall comply with Section 7. The service life of the buildings shall be not less than that determined using Table 10.3.5, except that the design life of long-life buildings shall be no less than 75 years.

9.5.1.1 LCA Performance Metric. The building chosen for the project shall have a 5% improvement over the other building alternate assessed in the LCA in a minimum of two of the impact categories. The impact categories are: land use (or habitat alteration), resource use, climate change, ozone layer depletion, human health effects, ecotoxicity, smog, acidification, and eutrophication.

9.5.1.2 Procedure. An LCA consists of the following three steps:

(a) Step 1: Perform a life cycle inventory (LCI). The LCI accounts for all the individual environmental flows to and from the products in a building throughout its life cycle.

1. The LCI shall include the materials and energy consumed and the emissions to air, land, and water for each of the following stages:

i. Extracting and harvesting materials and fuel sources from nature.

ii. Processing building materials and manufacturing building components.

iii. Transporting materials and components.

iv. Assembly and construction.

v. Operation including energy consumption, maintenance, repair, and replacement during the design life.

vi. Demolition, disposal, recycling, and reuse of the building at the end of its life cycle.

2. The LCI shall account for emissions to air for the following:

i. The six principle pollutants for which the USEPA has set National Ambient Air Quality Standards as required by the Clean Air Act and its amendments: carbon monoxide , nitrogen dioxide, lead , sulfur oxides , particulate matter (PM10 and PM2.5), and ozone.

ii. Greenhouse gases (not including water vapor and ozone) as described in the Inventory of U.S. Greenhouse Gas Emissions and Sinks: carbon dioxide, methane, nitrous oxide, chlorofluorocarbons, hydrochlorofluorocarbons, bromofluorocarbons, hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, sulfur dioxide, and VOCs.

iii. Hazardous air pollutants listed in the Clean Air Act and its amendments.

(b) Step 2: Compare the two building alternates using a published third-party impact indicator method that includes, at a minimum the impact categories listed in 9.5.1.1. An LCA report shall be prepared containing:

1. A description of the two building alternatives including:

i. a description of the system boundary used,

ii. the design life of each building, and

iii. the physical differences between buildings.

2. The impact indicator method and impact categories used, including an explanation of the rationale for choosing the categories used.

3. The results of the LCA indicating a minimum of 5% improvement in the proposed building compared to the other building alternate for a minimum of two impact categories, including an explanation of the rationale for the weighting and averaging of the impacts.

(c) Step 3: Conduct a critical review by an external expert independent of those performing the LCA.

9.5.1.3 Reporting. The following shall be submitted to the authority having jurisdiction:

(a) The LCA report.

(b) The documentation of critical peer review by a third party including the results from the review and the reviewer's name and contact information.

10. CONSTRUCTION AND OPERATION PLANS

10.1 Scope. This section specifies requirements for construction and operation plans including the commissioning process, building acceptance testing, measurement and verification, energy use reporting, durability, transportation management, erosion and sediment control, construction, and indoor air quality during construction.

10.2 Compliance. All of the provisions of Section 10 are Mandatory Provisions.

10.3 Mandatory Provisions

10.3.1 Building Project Commissioning

10.3.1.1 Scope. For buildings that exceed 500 m2 (5,000 ft2) of gross floor area, commissioning shall be performed in accordance with this section using generally accepted engineering standards and handbooks acceptable to the authority having jurisdiction.

A commissioning process shall be incorporated into the pre-design, design, construction, and first year occupancy of the building project that verifies that the delivered building and its components, assemblies, and systems comply with the documented owner's project requirements. Procedures, documentation, tools, and training shall be provided to the building operating staff to sustain features of the building assemblies and systems for the service life of the building.

10.3.1.2 Activities prior to Building Permit. The following activities shall be completed:

(a) Designate a project commissioning authority (CxA) to lead, review and oversee completion of the commissioning process activities prior to completion of schematic design.

(b) The owner, in conjunction with the design team as necessary, shall develop the owner’s project requirements (OPR) during predesign and updated during the design phase by the design team as necessary, in conjunction with the owner and the commissioning team. The OPR will be distributed to all parties participating in project design, construction, and operations, and the commissioning team members.

(c) The design team shall develop the basis of design (BOD).

(d) The CxA shall review both the OPR and BOD to ensure that no conflicting requirements or goals exist and that the OPR and BOD, based on the professional judgment and experience of the CxA, are sufficiently detailed for the project being undertaken.

(e) Commissioning requirements shall be incorporated into project specifications and other construction documents developed by the design team.

(f) The CxA shall conduct two focused OPR reviews of the construction documents: the first at near 50% design completion and the second of the final construction documents prior to delivery to the contractor. The purpose of these reviews is to verify that the documents achieve the construction phase OPR and the BOD document fully supports the OPR, with sufficient details.

(g) Develop and implement a commissioning plan containing all required forms and procedures for the complete testing of all equipment, systems and controls included in 10.3.1.5.

10.3.1.3 Activities prior to Building Occupancy. The following activities shall be completed:

(a) Verify the installation and performance of the systems to be commissioned, including completion of construction checklist and verification.

Exception: Systems that, because their operation is seasonally dependent, cannot be fully commissioned in accordance with the commissioning plan at time of occupancy. These systems shall be commissioned at the earliest time after occupancy when operation of systems is allowed to be fully demonstrated as determined by CxA.

(b) Verify the owner requirements for training operating personnel and building occupants are completed.

Exception: Training for systems whose operational seasonal dependence results in their not being fully commissioned at the time of occupancy shall have their training completed at earliest time after occupancy when operation of systems is allowed to be fully demonstrated as determined by CxA.

(c) Complete preliminary commissioning report.

(d) Verify a system manual has been prepared that includes O&M documentation, full warranty information and provides operating staff the information needed to understand and optimally operate the commissioned systems.

10.3.1.4 Post-Occupancy Activities. Complete the following:

(a) Complete any commissioning activities called out in the commissioning plan for systems whose commissioning can only be completed subsequent to building occupancy, including trend logging and off-season testing.

(b) Verify the owner requirements for training operating personnel and building occupants are completed for those systems whose seasonal operational dependence mean they were unable to be fully commissioned prior to building occupancy

(c) Complete a final commissioning report;

10.3.1.5 Systems. The following systems, if included in the building project, shall be commissioned:

(a) Heating, ventilating, air conditioning, IAQ and refrigeration systems (mechanical and/or passive) and associated controls. Control sequences to be verified for compliance with construction documentation as part of verification.

(b) Building envelope systems, components and assemblies to verify the thermal and moisture integrity.

(c) Building envelope pressurization to confirm air-tightness if included in basis of design requirements.

(d) All lighting controls and shading controls.

(e) Irrigation.

(f) Plumbing.

(g) Domestic and process water pumping and mixing systems.

(h) Service water heating systems.

(i) Renewable energy systems.

10.3.1.6 Documentation. Owner shall retain the System Manual and Final Commissioning Report for future use by owner and for local, state and federal agencies or their representatives that may request these data.

10.3.2 Building Acceptance Testing

10.3.2.1 Scope. For buildings 500 m2 (5,000 ft2) or less gross floor area, acceptance testing shall be performed in accordance with this section using generally accepted engineering standards and handbooks acceptable to the authority having jurisdiction.

An acceptance testing process shall be incorporated into the design and construction of the building project that verifies systems specified in this section perform in accordance with construction documents.

10.3.2.2 Activities prior to Building Permit. Complete the following:

(a) Designate a project Acceptance Agent to lead, review and oversee completion of the acceptance testing activities.

(b) Construction documents indicating clearly who is to perform acceptance tests and the details of the tests to be performed

(c) Acceptance Agent to review construction documents to verify relevant sensor locations, devices and control sequences are properly documented,

10.3.2.3 Activities prior to Building Occupancy. Complete the following:

(a) Verify proper installation and start-up of the systems

(b) Perform Acceptance Tests. For each Acceptance Test, complete test form and include a signature and license number, as appropriate, for the party who has performed the test.

(c) Verify a system manual has been prepared that includes O&M documentation, full warranty information and provides operating staff the information needed to understand and optimally operate building systems.

10.3.2.4 Systems. The following systems, if included in the building project, shall have Acceptance Testing:

(a) Mechanical Systems:

1. Heating, ventilating, air conditioning, IAQ, and refrigeration systems (mechanical and/or passive) and associated controls.

(b) Lighting Systems:

1. Automatic daylighting controls

2. Manual daylighting controls

3. Occupancy sensing devices, and

4. Automatic shut-off controls

(c) Renewable energy systems.

10.3.2.5 Documentation. Owner shall retain completed Acceptance Test forms for future use by owner and for local, state and federal agencies or their representatives that may request these data.

10.3.3 Measurement and Verification Plan. A preliminary plan shall be prepared and submitted to the owner prior to completion of design development, and a final plan at the completion of construction documentation. The owner is responsible for ensuring plan implementation after construction, documenting plan implementation and retaining a copy of the plan and implementation documentation both for owner's future use and for local, state and federal agencies or their representatives that may request this data.

10.3.3.1 Site Sustainability. Where trees and vegetation are used to comply with the shade requirements of 5.3.2.1, verify that this shade is obtained within 5 years after trees and vegetation are planted at project site.

10.3.3.2 Water Use Efficiency. For systems where metering is required in 6.3.3.1, the measurement and verification of water use is required in order to ensure that fixtures and other building equipment are operating as specified. This involves both the short-term measurement of specific equipment at the time of installation and permanent metering and sub-metering of major water using components at each facility within the project.

10.3.3.2.1 Water Consumption Baseline. After installation and commissioning of a metered and sub-metered piece of water-using equipment or system and subsequent to issuance of certificate of occupancy, measure water use through a complete operational cycle. This is allowed to be performed with any type of calibrated measurement device or water meter. The measured output shall serve as the baseline water use for comparison to on-going measured water consumption by metered and submetered water consuming equipment and systems.

Output from master meters and submeters and instrumentation shall be integrated into the master measurement and verification plans for the project. The output shall be displayed and recorded through electronic or other means such that consumption anomalies can be readily identified by facility operators on an ongoing basis.

10.3.3.2.2 Post-Occupancy Water Measurement and Verification. A maximum of 12 months after baseline water consumption values are established for any metered or sub-metered piece of water-using equipment or system the measured water consumption shall be compared against the predicted water consumption as identified in the baseline calculation. Any variations of 10% or greater in the baseline water consumption versus the actual measured water consumption shall be documented and corrective action taken by the facility operators where warranted. New baseline water consumption levels shall be established where building or operational conditions warrant such an adjustment. This new baseline water consumption data shall be fully documented and shall be used for future post-occupancy evaluations of water use. Subsequent evaluations of measured water consumption relative to the baseline shall be performed thereafter, a minimum of yearly after the initial evaluation.

10.3.3.2.3 Documentation of Water Efficiency.

(a) Document Section 10.3.3.2.1 initial baseline water measurement and verification (M&V) activities. Create report summarizing baseline water consumption data. Owner shall retain documentation for future use by owner and for local, state and federal agencies or their representatives that may request this data.

(b) Document Section 10.3.3.2.2 post-occupancy water consumption M&V activities. Create report summarizing measured meter and sub-meter consumption relative to baseline consumption, for the most recent post-occupancy period. These documents, along with a report of actions taken by facility operators and their results, shall be retained by owner for future post-occupancy evaluations and for any local, state and federal agencies or their representatives that may request this data.

(c) Retain all collected meter and sub-meter data for a minimum of 3 years.

10.3.3.3 Energy Efficiency. Use energy metering collection/storage infrastructure provided under 7.3.4 to collect and store meter data for each meter and sub-meter, starting no later than after the commissioning process has been completed and either occupancy certificate has been issued or a minimum of 80% of occupancy occurs.

Building projects whose size exceeds the applicable threshold in Table 10.3.3.3 shall perform energy measurement and verification activities in accordance with no less than one of the following two compliance paths:

(a) Benchmark performance against the USDOE Commercial Building Energy Consumption Survey (CBECS) database (Section 10.3.3.3.1).

(b) Benchmark performance using energy simulation model (Section 10.3.3.3.2).

10.3.3.3.1 CBECS Benchmarking Compliance Path. After 12 months and no later than 18 months after either certificate of occupancy has been issued or a minimum of 80% occupancy occurs, the owner shall compare whole building energy consumption data to other buildings of the same floor area and space type in the same climate region within the current CBECS database to determine relative building performance. The comparison shall be weather normalized and shall use default average values for all other building parameters (e.g. number of occupants, hours of operation, equipment loads, etc.) such as the USEPA Portfolio Manager for those building uses that are addressed in this program.

If the building is not rated in the top 8% of CBECS buildings on an energy consumption per unit area basis (92 or greater on the Energy Star Portfolio Manager scale), the owner shall retain the services of a CxA. The CxA shall analyze systems operation and document for the owner reasons why whole building performance does not comply with criteria, along with recommendations for actions that would correct performance. The CxA shall submit a commissioning report documenting system deficiencies to the authority having jurisdiction and to the owner.

Subsequent evaluations of whole building measured energy performance relative to CBECS shall be performed thereafter, a minimum of every three years after the initial evaluation.

10.3.3.3.2 Energy Simulation Compliance Path.

10.3.3.3.2.1 Initial Measurement and Verification. Perform the following to baseline energy performance:

Table 10.3.3.3 Threshold for Energy M&V Evaluation

Building Usage

Category

M&V
Threshold,

m2 (ft2)

Food Service (Restaurant)/

Food Sales (Grocery Store)

Health Care

Inpatient Health

>2,000
(20,000)

Lodging

Office

Public Order & Safety

Outpatient Health

Public Assembly

Education

> 4,000
(40,000)

Retail

Religious Worship

> 5,000
(50,000)

Warehouse

Non-Refrigerated Storage

> 8,000
(80,000)

Other*

> 2,000
(20,000)

*For buildings in “Other” category, threshold is allowed to be raised to 4,000 m2 (40,000 ft2) if the
whole building annual energy intensity is less than 250 kWh/m2 (80,000 Btu/ft2).

After 12 months and no later than 18 months after meter data collection begins, compare all measured energy consumption from the main meters and sub-meters against the predicted energy consumption of the systems and subsystems, as obtained by an energy simulation model for the whole building. If an existing building energy simulation model has been created previously (e.g., to satisfy performance requirements of 7.5), this model is allowed to be re-used; otherwise, a new energy simulation model shall be created using as-built construction documentation and following the modeling methodology and requirements referenced in 7.5.

Variations of 10% or more in the predicted annual energy consumption versus measured energy consumption and/or variations of 20% or more in peak demand or consumption for any individual month shall be documented. If required in order to reconcile measured building energy meter data to the energy model predicted values, provide short-term metering for sub-systems and process loads that do not have permanent metering per 7.3.3, documenting findings.

Establish an updated baseline for monthly and annual energy consumption and demand for the building at the building boundary. Correct and calibrate the energy simulation model for each major energy consuming system by normalizing based on actual weather and operational conditions (e.g., use and occupancy patterns, equipment operating schedules) during the timeframe meter data was collected so it matches the energy baseline within 10% annually and within 20% for each individual month.

10.3.3.3.2.2 Post Occupancy Measurement and Verification Evaluation.

Perform periodic post-occupancy evaluations of energy performance as follows:

(a) three years after receiving the certificate of occupancy or a minimum of 80% of occupancy, whichever is later, then

(b) subsequent post-occupancy evaluations of energy performance shall be performed a minimum of every three years.

Evaluate building energy monthly consumption and peak demand and system and sub-system performance using meter and sub-meter data (collected for the prior 12 months, the “occupancy period”) relative to baseline monthly energy consumption and peak demand data established under 10.3.3.3.1. The impact of any functional changes that might have occurred during or prior to the occupancy period shall be documented and credited or debited against the baseline monthly energy consumption and peak demand data and actual weather data for the occupancy period used to adjust baseline energy use. If the measured results are not within the 10% of the established baseline annual energy use or within 20% of the established baseline monthly energy consumption and peak demand, the owner shall retain the services of a CxA. The CxA shall analyze systems operation and document for the owner reasons why deviations exceed maximums for any metered energy using system, along with recommendations for actions that would correct any documented degradation in systems’ performance.

Where the building or the building's use changes significantly enough over time to warrant permanent adjustment to the energy baseline, a new energy baseline is allowed to be established using procedures established in 10.3.3.3.1 and occupancy period meter data. This new baseline energy consumption data shall be documented and shall be used for future post-occupancy evaluations of building energy performance.

10.3.3.3.3 Documentation of Energy Efficiency.

(a) If performance has been benchmarked using the CBECS compliance path in 10.3.3.3.1, document the CBECS benchmarking M&V activities. Create report documenting measured annual energy use intensity for the overall building and by fuel, in kWh/m2 (kBtu/ft2), along with comparison of building performance relative to appropriate CBECS data set. These documents, along with the CxA's report, shall be retained by owner for future post-occupancy evaluations by owner and for any local, state and federal agencies or their representatives.

(b) If performance has been benchmarked using the energy simulation compliance path in 10.3.3.3.2, then:

1. Document 10.3.3.3.2.1initial baseline energy simulation M&V activities. Create reports summarizing measured meter and sub-meter data and baseline energy consumption data, with metrics summarizing the baseline annual energy use intensity for the overall building and by fuel, in kWh/m2 (kBtu/ft2). Owner shall retain documentation for future use by owner and for local, state and federal agencies or their representatives that may request this data.

2. Document 10.3.3.3.2.2 post-occupancy energy simulation M&V activities. Create reports summarizing measured meter and sub-meter relative to baseline energy consumption along with metrics of corrected baseline annual energy use for the overall building and by fuel, in kWh/m2 (kBtu/ft2), for the occupancy period. These documents, along with the CxA's report, shall be retained by owner for future post-occupancy evaluations by owner and for any local, state and federal agencies or their representatives.

(c) Retain all collected meter and sub-meter data for a minimum of 3 years.

10.3.3.4 Indoor Environmental Quality (IEQ). An Indoor Air Quality (IAQ) Management Plan shall be developed and implemented. The plan shall develop and document procedures for implementing a regular monitoring program after building occupancy using the equipment required for monitoring of CO2 levels or outdoor air flow specified under 8.3.3. The plan procedures shall contain the following:

(a) For spaces being mechanically ventilated that are required to conduct CO2 monitoring in 8.3.3, a procedure shall be in place to react to elevated CO2 levels by temporarily increasing the outdoor air flow for the ventilation system. The procedure shall include the definition of the action level for elevated CO2 concentrations for each zone. The action level concentration for each zone shall be taken from Table E-1 in

Appendix E.
The CO_2 concentration data shall also be reviewed on a regular basis, but no less frequently than monthly. If CO_2 levels are found to be elevated, adjustments to the ventilation system equipment shall be made and the CO_2 levels shall be checked daily for a minimum of one week to ensure the system is back in compliance with the ventilation requirements of 8.3.3.1. In addition, check operation of all CO_2 sensors annually and recalibrate or replace sensing elements for all CO_2 sensors at the manufacturer's recommended interval or a minimum of every 5 years, whichever is shorter.

Exception to 10.3.3.4(a): The outdoor air ventilation rate is not required to be larger than the design outdoor air ventilation rate required by complying with 8.3.1, regardless of CO_2 concentration.

(b) For each mechanical ventilation system where direct outdoor airflow measurement is required according to 8.3.3, a procedure shall be in place to react to when the outdoor airflow is 15% or more lower than design minimum outdoor airflow rate, as defined by 8.3.1. Verify that the device which measures outdoor air flow is actually measuring the flow rate within ±15% of the sensor output reading at the design minimum outdoor airflow rates specified in 8.3.1. If the sensor is not within ±15%, then recalibrate the sensor.
Verification of outdoor airflow shall be done on a quarterly basis and records maintained on-site. Recalibrate direct outdoor airflow measurement devices at the manufacturer's recommended interval or a minimum of annually.

(c) For naturally ventilated spaces, a procedure shall be in place to conduct CO2 monitoring and react to elevated CO2 levels. The procedure shall include also the definition of the action level for elevated CO2 concentrations for each zone. The action level concentration for each zone shall be taken from Table E-1 in Appendix E. CO2 levels shall be checked at least monthly to verify the natural ventilation system has the capability to properly ventilate spaces. During the first full year of occupancy, after receipt of final certificate of occupancy, the CO2 levels shall be checked on a weekly basis to verify the natural ventilation system operation. If elevated concentration levels are found, verify with building occupants (for manual natural ventilation systems) and/or through the energy management system that natural ventilation strategies are being followed per design intent. If, when operated properly, spaces are found that cannot be ventilated sufficiently to lower concentration levels, retain the services of an independent third-party (e.g., a consulting engineer or the CxA) to review system operations and provide recommendations for needed modifications. After the first full year of occupancy, the CO2 levels shall be checked on a monthly basis. In addition, check all CO2 sensors functioning annually and recalibrate or replace sensing elements at the manufacturer's recommended interval or a minimum of every five years, whichever is shorter.

(d) The IAQ Management Plan shall include a list of each zone or building space that requires CO2 monitoring, as defined in 8.3.3.

(e) The outdoor ambient CO2 concentration shall be determined either through direct measurement or by assuming that the ambient concentration is 400 ppm.

(f) Owner shall maintain following documentation for IEQ measurement and verification:

1. IEQ Measurement and Verification Plan, including:

i. A list of each zone or building space that requires CO_2 monitoring, the action level concentration for each zone.

ii. A list of each air system requiring outdoor air flow measurement.

iii. Monitoring procedures and monitoring frequencies for each monitored sensing device, including a description of the specific response measures to be taken if needed.

2. Dated records of CO_2 concentrations and airflow rates measured and reviewed as part of the above listed requirements, along with dated documentation of any corrective actions taken and any sensor recalibrations or replacements.

All IEQ measurement and verification data and documentation shall be made available to local, state and federal agencies, or their representatives, that may request it.

10.3.3.5 The Building's Impact on the Atmosphere, Materials and Resources.

There shall be an annual verification that areas for recyclables (9.3.4.1), reusable goods (9.3.4.2), and fluorescent and HID lamps and ballasts (9.3.4.3) are maintained. Certificates of lamp and ballast recycling shall be maintained by owner on an ongoing basis, beginning with the first lamp and ballast retrofit and/or replacement project within the building. These certificates shall be made available to local, state and federal agencies, or their representatives.

10.3.4 Energy Use Reporting. The project owner shall enter the building's annual energy use into the Environmental Protection Agency's Energy Star Portfolio Manager Tool every third year after initial the building commissioning process has been completed and either the occupancy certificate has been issued or a minimum occupancy of 80% is reached for the life of the building. Owner shall print and retain input and summary report pages from Portfolio Manager for their building on each occasion when annual energy use data is entered. This documentation shall be made available to local, state or federal agencies, or their representatives, that may request it.

Exception to 10.3.4: Building types not included in Energy Star Portfolio Manager are excluded from this reporting requirement.

10.3.5 Service Life Plan. A service life plan that is consistent with the owner's project requirements shall be developed to estimate to what extent structural, building envelope (but not mechanical and electrical), and hardscape materials will need to be repaired or replaced during the service life of the building. The design service life of the building shall be no less than that determined using Table 10.3.5. The estimated service life shall be specified for building assemblies, products, and materials that will need to be inspected, repaired and/or replaced during the service life of the building. Site improvements and hardscape shall also be included. Documentation in the service life plan shall include the project design service life and basis for determination, and the following for each assembly or component:

(a) Building assembly description.

(b) Materials or products.

(c) Design or estimated service life, years.

(d) Maintenance frequency.

(e) Maintenance access for components with an estimated service life less than the service life of the building.

The service life plan shall be submitted to the owner for approval prior to the completion of design development. Owner shall retain a copy of the service life plan for use during the life of building and for local, state and federal agencies or their representatives that may request this data.

TABLE 10.3.5 Minimum Design Service Life for Buildings

Category	Minimum Service Life	Building Types
Temporary	Up to 10 Years	* Non-permanent construction buildings (sales offices, bunkhouses) * Temporary exhibition buildings
Medium life	25 Years	* Industrial buildings * Stand-alone parking structures
Long life	50 Years	* All buildings not temporary or medium life, including the parking structures below buildings designed for long life category

10.3.6 Transportation Management Plan (TMP). A transportation management plan shall be developed compliant with the following requirements. The transportation management plan shall be submitted to the owner for approval prior to the completion of design development. Owner shall retain a copy of the transportation management plan for use during the life of the building and for local, state and federal agencies or their representatives that request this data.

10.3.6.1 Building owner. The building owner shall:

(a) Offer at least one of the following primary benefits to the owner's employees:

1. Offer to pay at least $30 per month towards a transit pass, or the full cost of a pass if it is less than $30, to each employee who commutes using transit,

2. Offer to pay at least $30 per month towards a vanpool pass, or the full cost of a pass if it is less than $30, to each employee who commutes in a van,

3. Offer a significant telework program that reduces by at least 6 percent the number of commuting trips employees make,

4. Offer to pay at least $30 per month, in lieu of providing a parking spot, to each employee who leaves his/her car at home and commutes another way,

5. Offer an equivalent benefit that provides similar value to employees, and reduces traffic and air pollution.

(b) Offer at least three of the following supporting benefits to the owner's employees, applicable to employers with at least 20 employees:

1. Active membership in a transportation management association or participation in a voluntary regional air quality program or another employer-based commuter program,

2. Active membership in a local ozone awareness program, notifying employees of expected poor air quality and suggesting ways they might minimize polluting behaviors,

3. Ridesharing or carpool matching, either in-house or through an outside organization,

4. Pre-tax transit subsidy deducted from employee paycheck,

5. Pre-tax vanpool subsidy deducted from employee paycheck,

6. Transit benefits of less than $30 per month, or less than the full cost if less than $30,

7. Vanpool benefits of less than $30 per month, or less than the full cost if less than $30,

8. Cash in lieu of an employer-provided parking spot in an amount less than $30 per month, or less than 75 percent of the actual parking benefit,

9. Shuttles from transit stations, either employer-provided or through a local TMA or similar service provider,

10. Parking at park-and-ride lots or vanpool staging areas,

11. Provision of intelligent, real-time, commuting information,

12. Preferred parking for carpools and vanpools,

13. Reduced parking for carpools and vanpools,

14. Employer-supported vanpools – provided in-house,

15. Employer-supported vanpools – provided by an outside organization,

16. Employer-provided membership in a carsharing program,

17. Secure bicycle parking, showers, and lockers,

18. Electric bicycle recharging stations,

19. Employee commuting awards programs,

20. Discounts and coupons for bicycles for bicyclists or shoes for walkers,

21. Compressed work schedules,

22. Telework that reduces commute trips by less than 6 percent,

23. Lunchtime shuttles,

24. Proximate commute, where employees work at locations closer to their homes,

25. Incentives to encourage employees to live closer to work,

26. Incentives to encourage employees to use alternative transportation,

27. On-site amenities,

28. Concierge services.

(c) Provide all of the following to the owner's employees:

1. Access to an Emergency Ride Home for employees, either provided in-house or by an outside organization

2. A central point of contact in charge of commuter benefits

3. Maintenance of commuter benefits in a centralized location

4. Active promotion of commuter benefits to employees

5. Commitment to ensuring that within 18 months at least 14 percent of employees will not be driving alone to work.

10.3.6.2. Building tenant. The building owner:

(a) shall provide a copy of a transportation management plan compliant with 10.3.6.1 to tenants within the building.

(b) shall not include parking fees in lease rates.

10.3.7 Erosion and Sediment Control (ESC) Plan. Prepare and implement an Erosion and Sediment Control (ESC) plan for all construction activities. The ESC plan shall conform to the erosion and sedimentation control requirements of the most current version of the USEPA NPDES General Permit for Stormwater Discharges From Construction Activities or local erosion and sedimentation control standards and codes, whichever is more stringent and regardless of size of project.

10.3.8 Indoor Air Quality (IAQ) Construction Management Plan. An Indoor Air Quality (IAQ) Construction Management Plan shall be developed and implemented as follows:

(a) The plan for IAQ during construction shall be acceptable to the authority having jurisdiction.

(b) Cleanliness standards for all HVAC air conveyance elements shall be followed during construction. A cleanliness specification—based on the cleanliness requirements of the building—shall provide details for the storage and covering of air conveyance elements. Permanent HVAC shall never be used during construction and shall be operated for the first time during building “flush-out” and then only after all filters and controls are in place and operational.

(c) After construction ends, prior to occupancy and with all interior finishes installed, a building flush-out shall be performed by one of the following methods:

1. Supplying a total air volume of 4,300 m3 of outdoor air per m2 of floor area (14,000 ft3 of outdoor air per ft2 of floor area) while maintaining an internal temperature of a minimum of 15 C (60 ºF) and relative humidity no higher than 60% or as in 10.3.8.1(d) or 10.3.8.1(e).

2. If occupancy is desired prior to completion of the flush-out, the space is allowed to be occupied following delivery of a minimum of 1,100 m3 of outdoor air per m2 of floor area (3,500 ft3 of outdoor air per ft2 of floor area) to the space. Once a space is occupied, it shall be ventilated at a minimum rate of 1.5 L/s per m2 (0.30 cfm per ft2) of outdoor air or the design minimum outdoor airflow rate

determined in 8.3.1(a), whichever is greater. During each day of the flush-out period, ventilation shall begin a minimum of three hours prior to occupancy and continue during occupancy. These conditions shall be maintained until a total of 4,300 m3 of outdoor air per m2 of floor area (14,000 ft3 of outdoor air per ft2 of floor area) has been delivered to the space.

3. Baseline IAQ testing shall be conducted after construction ends and prior to occupancy using testing protocols consistent with the USEPA Compendium of Methods for the Determination of Air Pollutants in Indoor Air. The testing shall demonstrate that the contaminant maximum concentrations listed in Table 10.3.8 are not exceeded. For each sampling point where the maximum concentration limits are exceeded conduct additional flush-out with outside air and retest the specific parameter(s) exceeded to indicate the requirements are achieved. Repeat procedure until all requirements have been met. When retesting non-complying building areas, take samples from the same locations as in the first test.

TABLE 10.3.8 Maximum Concentration of Air Pollutants

Contaminant	Maximum Concentration
Formaldehyde	50 parts per billion
Particulates (PM10)	50 mcg/m3 (50 ppb)
Total Volatile Organic Compounds (TVOC)	500 mcg/m3 (500 ppb)
4-Phenylcyclohexene (4-PCH)a	6.5 mcg/m3 (6.5 ppb)

Carbon Monoxide (CO)

9 ppm and no greater than 2 ppm above outdoor
levels

a This test is only required if carpets and fabrics with styrene butadiene rubber (SBR) latex backing
material are installed as part of the base building systems.

10.3.9 Construction. The following shall be adhered to during project construction.

10.3.9.1 Construction Activity Pollution Prevention: No-idling of Construction Vehicles. Operators of diesel construction vehicles are not allowed to idle their vehicles' engines during any part of the building's construction. Vehicle staging areas shall be established for waiting to load or unload materials. These staging areas shall be located 30 m (100 ft) from any outdoor air intakes, operable openings, and hospitals, schools, residences, hotels, daycare facilities, elderly housing, and convalescent facilities. No load/unload location owner shall cause vehicles covered by this provision to idle for a period greater than 15 minutes while waiting to load or unload at a location under their control. No owner or operator of a vehicle shall cause or permit vehicles covered by this provision to idle for more than 5 consecutive minutes in any 60-minute period.

Exception to 10.3.9.1: Construction vehicles may idle in the following instances:

(a) while forced to remain motionless at the direction of a law enforcement
official.

(b) when operating defrosters, heaters, air conditioners, or installing equipment solely to prevent a safety or health emergency, and not as part of a rest period.

(c) the primary propulsion engine idles for maintenance, servicing, repairing, or diagnostic purposes if idling is required for such activity.

(d) idling of the primary propulsion engine is necessary to power work-related mechanical or electrical operations other than propulsion (e.g., mixing or processing cargo or straight truck refrigeration, including hoisting and lifting operations, or straight truck refrigeration). This exemption does not apply when idling for cabin comfort or to operate non-essential on-board equipment.

(e) for purposes of air conditioning or heating while waiting to load or unload.

(f) due to mechanical difficulties over which the driver has no control.

(g) idling of a vehicle is required to comply with an applicable existing local, state or federal safety, health, environmental, or trade union requirement.

10.3.9.2 Moisture Control. The following items to control moisture shall be implemented during construction:

(a) Materials stored on-site or materials installed that are absorptive shall be protected from moisture damage.

(b) Building construction materials which show visual evidence of biological growth due to the presence of moisture shall be cleaned, or shall be removed and discarded and then replaced.

(c) Landscaping sprinklers shall not be permitted to spray water on a building and within 1 m (3 feet) of a building.

10.4 Prescriptive Option. There are no prescriptive criteria.

10.5 Performance Option. There are no performance criteria.

11. NORMATIVE REFERENCES

Reference

Title

Section

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE),
1791 Tullie Circle NE
Atlanta, GA 30329
United States
1-404-636-8400; www.ashrae.org

ASHRAE Standard 52.2-2007

Method of Testing General Ventilation Air-Cleaning
Devices for Removal Efficiency by Particle Size

8.3.1

ASHRAE Standard 55-2004

Thermal Comfort Conditions for Human Occupancy

8.3.4, 8.6.4

ASHRAE Standard 62.1-2007

Ventilation for Acceptable Indoor Air Quality

3.2, 8.3.1,
8.6.1,
Appendix E

ASHRAE/IESNA Standard 90.1-2007

Energy Standard for Buildings
Except Low-Rise Residential Buildings

3.1, 3.2,
7.3.1, 7.4.1,
7.4.2, 7.4.3,
7.4.4, 7.4.5,
7.4.6, 7.4.7,
7.4.8, 7.6.1,
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7.6.10,
7.6.11,
7.6.12,
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A,
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Appendix D

ASHRAE Standard 140-2004

Standard Method of Test for the Evaluation of
Building Energy Analysis Computer Programs

Appendix D

ASHRAE Standard 169-2006

Weather Data for Building Design Standards

Appendix
A,
Appendix C

American Society of Mechanical Engineers (ASME)

Three Park Avenue

New York, NY 10016-5990
United States
1-800-843-2763 and 1-973-882-1170; www.asme.org

ASME A112.18.1-2005/CSA B125,1-05

Plumbing Supply Fittings

6.3.2.1

ASME A112.19.2-2003

Vitreous China Plumbing Fixtures and Hydraulic
Requirements for Water Closets and Urinals

6.3.2.1

ASME A112.19.19-2006

Vitreous China Nonwater Urinals

6.3.2.1

American Society for Testing and Materials

100 Barr Harbor Dr.

West Conshohocken, PA 19428-2959
United States
1-610-832-9585; www.astm.org

ASTM C518-04

Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus

Appendix C

ASTM C1371-04a

Standard Test Method for Determination of Emittance of Materials Near Room Temperature Using Portable Emissometers

5.3.2,
Appendix D

ASTM C1549-04

Standard Test Method for Determination of Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer

5.3.2,
Appendix D

ASTM D1003-00

Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics

8.3.7,
8.4.1.2

ASTM E90-04

Standard Test Method for Laboratory Measurement of
Airborne Sound Transmission Loss of Building
Partitions and Elements

8.3.6

ASTM E408-71(2002)

Standard Test Methods for Total Normal Emittance of
Surfaces Using Inspection-Meter Techniques

5.3.2,
Appendix D

ASTM E413-04

Classification for Rating Sound Insulation

8.3.6

ASTM E779-03

Standard Test Method for Determining Air Leakage
Rate by Fan Pressurization

Appendix B

ASTM E1332-90 (2003)

Standard Classification for the Determination of
Outdoor-Indoor Transmission Class

8.3.6

ASTM E1677-05

Standard Specification for an Air Retarder (AR)
Material or System for Low-Rise Framed Building
Walls

Appendix B

ASTM E1903-97 (2002)

Standard Guide for Environmental Site Assessments: Phase II Environmental Site Assessment Process

3.2, 5.6.1

ASTM E1918-06

Standard Test Method for Measuring Solar Reflectance of Horizontal and Low-Sloped Surfaces in the Field

5.3.2,
Appendix D

ASTM E1980-01

Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-Sloped Opaque Surfaces

5.3.2,
Appendix D

ASTM E2178-03

Standard Test Method for Air Permeance of Building Materials

Appendix B

ASTM E2357-05

Standard Test Method for Determining Air Leakage of Air Barrier Assemblies

Appendix B

ASTM F2324-03

Standard Test Method for Prerinse Spray Valves

6.4.2.2

California Department of Health Services (CDHS)

P. O. Box 997413

Sacramento, CA 95899-7413

United States

1-916-445-4171; www.dhs.ca.gov

California Specification 01350 - July 15,
2004

Standard Practice for the Testing of Volatile Organic
Emissions from Various Sources Using Small-Scale
Environmental Chambers

8.4.2.3,
8.5.2

CITES Secretariat
International Environment House
Chemin des Anémones
CH-1219 Châtelaine, Geneva
Switzerland

41-(0)22-917-81-39/40; www.cites.org

3 March 1973 Amended at Bonn, on 22 June 1979, with Appendices I, II and III valid from 4 March 2007

Convention on International Trade in Endangered Species of Wild Fauna and Flora

9.3.2

Cooling Tower Technology Institute (CTI)
P.O Box 73383
Houston, TX 77273
United States
1-281-583-4087; www.cti.org

CTI ATC-105 (2/2000)

Acceptance Test Code

Appendix C

CTI STD 201 (9/2004)

Standard for the Certification of Water Cooling Tower
Thermal Performance

Appendix C

Green Seal

1001 Connecticut Avenue, NW, Suite 827

Washington, DC 20036-5525

United States

1-202-872-6400; www.greenseal.org

GS-11, May 20, 1993

Standard for Paints

8.4.2.2

GS-36, October 19, 2000

Standard for Commercial Adhesives

8.4.2.1

International Association of Plumbing and Mechanical Officials (IAPMO)
5001 East Philadelphia Street
Ontario, CA 91761

United States

1-909-472-4100; www.iapmo.org

Z124.9-2004

Plastic Urinal Fixtures

6.3.2.1

International Standards Organization (ISO),
ISO Central Secretariat, 1 rue de Varembee, Case postale 56

CH-1211 Geneva 20

Switzerland

41-22-749-01-11; www.iso.org

ISO 14044 – 2006

Environmental management — Life cycle assessment
— Requirements and guidelines

9.5.1

ISO/IEC Guide 59-1994

Code of Good Practice for Standardization

9.4.1.3

Irrigation Association (IA)

6540 Arlington Boulevard

Falls Church, VA 22042-6638
United States
1-703-536-7080; www.irrigation.org

Smart Water Application Technology
(SWAT) Climatological Based Controllers
7th Draft Testing Protocol – November 2006

Smart Water Application Technology (SWAT), Turf and Landscape Irrigation Equipment Climatologically Based Controllers

6.3.1.3

Scientific Certification Systems (SCS)

2000 Powell Street, Suite 1350

Emeryville, CA 94608

United States

1-510-452-8000; www.scscertified.com

SCS-EC10.2-2007

Environmental Certification Program, Indoor Air Quality Performance

8.4.2.3

Solar Rating and Certification Council (SRCC)

c/o Florida Solar Energy Center (FSEC)

1679 Clearlake Rd

Cocoa FL 32922-5703
United States
1-321-638-1537; 1-321-638-1010; www.solar-rating.org

SRCC Document OG-100

Operating Guidelines for Certifying Solar Collectors

7.3.2

South Coast Air Quality Management District (SCAQMD)

California Air Resources Board

1001 "I" Street

P.O. Box 2815

Sacramento, CA 95812

United States

1-916-322-2990; www.arb.ca.gov

SCAQMD 1113- Amended June 9, 2006

Architectural Coatings

8.4.2.2

SCAQMD 1168 - amended January 7, 2005

Adhesive and Sealant Applications

8.4.2.1

United States Department of Agriculture (USDA)

BioPreferred

2272 Howe Hall, Suite 2620

Ames, Iowa 50011-2272
United States
1-877-251-6522, 515-294-5416; www.usda.gov/biobased

7 CFR Part 2902, March 16, 2006 (Round 1),
August 17, 2006 (Rounds 2 and 3), and
October 11, 2006 (Round 4)

Designation of Biobased Items for Federal
Procurement

9.4.1.3

United States Department of Energy (USDOE)

Energy Information Administration

Washington, DC 20585

United States

1-202-586-5000; www.eia.doe.gov/emeu/cbecs/contents.html;
http://tonto.eia.doe.gov/state

2003

Commercial Building Energy Consumption Survey
(CBECS)

10.3.3.3

State and U.S. Historical Data

Appendix D

United States Environmental Protection Agency (USEPA)
Ariel Rios Building
1200 Pennsylvania Avenue, N.W.
Washington, DC 20460

1-919-541-0800; www.epa.gov

Energy Star 1-888-782-7937

WaterSense 1-866-987-7367 and 1-202-564-2660

1970 and as amended in 1990

Clean Air Act

8.5.1.2

Code of Federal Regulations, Title 40 Part 50
(40 CFR 50), as amended July 1, 2004

National Primary and Secondary Ambient Air Quality
Standards

8.3.1

January 21, 2005

NPDES General Permit for Stormwater Discharges
From Construction Activities

10.3.7

Version 3.0, July 1, 1999

Energy Star Computer Memorandum of
Understanding

7.4.7

Version 2.0

Energy Star Copier Memorandum of Understanding

7.4.7

Amendment October 23, 1998

Energy Star Memorandum of Understanding for
Multifunction Devices

7.4.7

Version 3.0, November 1 2000

Energy Star Printer, Fax, Printer/Fax, and Mailing
Machine Memorandum of Understanding

7.4.7

November 16, 2005

Energy Star Program Requirements and Criteria for Room Air Conditioners

7.4.7

Version 4.0

Energy Star Program Requirements for ASHPs and Central Air Conditioners

7.4.7

Version 2

Energy Star Program Requirements for Boilers

7.4.7

Version 1.1

Energy Star Program Requirements for Bottled Water Coolers

7.4.7

Version 3.0, January 1, 2004

Energy Star Program Requirements for CFLs

7.4.7

December 20, 2005

Energy Star Program Requirements for Clothes Washers

6.3.2.2,
7.4.7

Energy Star Program Requirements for Commercial and Industrial Transformers

7.4.7

October 11, 2007

Energy Star Program Requirements for Commercial Dishwashers

6.4.2.2,
7.4.7

Version 1.0, August 15, 2003

Energy Star Program Requirements for Commercial Fryers

7.4.7

Version 1.0, July 25, 2007

Energy Star Program Requirements for Commercial Ice Machines

6.4.2.2,
7.4.7

Version 1.0, August 1, 2003

Energy Star Program Requirements for Commercial Steam Cookers

7.4.7

Version 4.1, January 1, 2006

Energy Star Program Requirements for Computer Monitors

7.4.7

Version 1.0

Energy Star Program Requirements for Consumer Audio and DVD

7.4.7

Version 2.0, October 1 2006

Energy Star Program Requirements for Dehumidifiers

7.4.7

February 24, 2004

Energy Star Program Requirements for Dishwashers

6.3.2.2,
7.4.7

Version 2.0

Energy Star Program Requirements for Furnaces

7.4.7

April 1, 2001

Energy Star Program Requirements for Geothermal Heat Pumps

7.4.7

Version 1.0, August 15, 2003

Energy Star Program Requirements for Hot Food Holding Cabinets

7.4.7

January 1, 2004

Energy Star Program Requirements for Light Commercial HVAC

7.4.7

January 1 2006

Energy Star Program Requirements for Products with Battery Charger Systems (BCSs)

7.4.7

Energy Star Program Requirements for Programmable Thermostats

7.4.7

Version 2.0

Energy Star Program Requirements for Refrigerated Beverage Vending Machines

7.4.7

September 1 2001

Energy Star Program Requirements for Refrigerators and Freezers

7.4.7

Version 2.1, September 1, 2006

Energy Star Program Requirements for Residential Ceiling Fans

7.4.7

Version 1.2

Energy Star Program Requirements for Roof Products

5.3.2.3

Version 1, July 1 2004

Energy Star Program Requirements for Room Air Cleaners

7.4.7

Version 4.0, October 1, 2005

Energy Star Program Requirements for Residential Light Fixtures

7.4.7

Version 2.0 January 1, 2005

Energy Star Program Requirements for Residential Ventilating Fans

7.4.7

Version 1.1

Energy Star Program Requirements for Single-Voltage AC-DC and AC-AC Power Supplies

7.4.7

Version 1.0, September 1, 2001

Energy Star Program Requirements for Solid Door Refrigerators and Freezers

7.4.7

Version 2.0, November 1, 2006

Energy Star Program Requirements for Telephony

7.4.7

Version 1.1

Energy Star Program Requirements for Traffic Signals

7.4.7

Version 2.2

Energy StarProgram Requirements for TVs, VCRs,

DCR TVs with POD Slots, Combination Units,
Television Monitors, and Component Television Units

7.4.7

Version 1.0 April 1, 1997

Energy Star Scanner Memorandum of Understanding

7.4.7

Version 1.0, October 4, 2007

WaterSense Tank-Type High-Efficiency Lavatory
Specification

6.3.2.1

Version 1.0, January 24, 2007

WaterSense Tank-Type High-Efficiency Toilet
Specification

6.3.2.1

United States Environmental Protection Agency (USEPA)

Atmospheric Research and Exposure Assessment Laboratory

Research Triangle Park, NC 27711

United States
1-919-541-2258; www.epa.gov

EPA 600/4-90-010, April 1990

Compendium of Methods for the Determination of Air
Pollutants in Indoor Air

10.3.8

U. S. Government Printing Office

Washington, D.C. 20401

United States

+1 (202) 512-0000; www.access.gpo.gov

http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=109_cong_bills&docid=f:h6enr.txt.pdf

2005

Energy Policy Act (EPAct)

7.4.7

World Trade Organization (WTO)
Centre William Rappard,
Rue de Lausanne 154,
CH-1211 Geneva 21,
Switzerland

41-22-739-51-11; www.wto.org

1994

WTO Technical Barriers to Trade (TBT) Agreement
Annex 3

9.4.1.3

(This is a normative appendix and is part of this standard.)

NORMATIVE APPENDIX A

PRESCRIPTIVE BUILDING ENVELOPE TABLES

(Informative note: The first 9 tables are in SI units, the next 9 tables are in I-P units.)

For climate zones, see Section 5.1.4 of ASHRAE/IESNA Standard 90.1 and Normative Appendix B of ASHRAE Standard 169.

(a) For the United States, the ASHRAE Standard 169 climate zone map is reproduced above. A list of counties and their respective climate zones can be found in Table B1 in ASHRAE Standard 169.

(b) For Canada, see Table B2 in ASHRAE Standard 169.

(c) For available international locations (outside the U.S. and Canada), see Table B3 in ASHRAE Standard 169.

(d) For locations not provided in Table B2 or B3, see Table B4 (reproduced below) in ASHRAE Standard 169 for the international climate zone definitions.

Table B-4 International Climate Zone Definitions

Climate Zone Number	Name	Thermal Criteria (SI)	Thermal Criteria (I-P)
1	Very Hot – Humid (1A), Dry (1B)	5000 < CDD10 C	9000 < CDD50ºF
2	Hot – Humid (2A), Dry (2B)	3500 < CDD10 C = 5000	6300 < CDD50ºF < 9000
3A, 3B	Warm – Humid (3A), Dry (3B)	2500 < CDD10 C = 3500	4500 < CDD50ºF < 6300
3C	Warm – Marine (3C)		

CDD10 C = 2500 AND

HDD18 C = 2000

CDD50ºF = 4500 AND

HDD65ºF = 3600

4A, 4B

Mixed –
Humid (4A), Dry (4B)

2500 = CDD10 C AND

2000 < HDD18 C = 3000

CDD50ºF < 4500 AND

3600 < HDD65ºF < 5400

4C

Mixed –
Marine (4C)

2000 < HDD18 C = 3000

3600 < HDD65ºF < 5400

5A, 5B, 5C

Cool– Humid (5A),
Dry (5B), Marine (5C)

3000 < HDD18 C = 4000

5400 < HDD65ºF < 7200

6A, 6B

Cold –
Humid (6A), Dry (6B)

4000 < HDD18 C = 5000

7200 < HDD65ºF < 9000

7

Very Cold

5000 < HDD18 C = 7000

9000 < HDD65ºF < 12600

8

Subarctic

7000 < HDD18 C

12600 < HDD65ºF

Table A-1 (supersedes Table 5.5-1 in ASHRAE/IESNA Standard 90.1)

Building Envelope Requirements For Climate Zone 1 (A,B) (SI)

Nonresidential

Residential

Semiheated

Assembly

Insulation

Assembly

Insulation

Assembly

Insulation

Opaque Elements

Max.

Min. R-Value

Max.

Min. R-Value

Max.

Min.R-Value

Roofs

Insulation Entirely above Deck

U-0.27

R-3.5 ci

U-0.22

R-4.4 ci

U-0.98

R-0.9 ci

Metal Building

U-0.28

R-2.3 + R-3.3

U-0.23

R-3.3 + R-1.8
filled cavity w/tbd

U-0.47

R-2.3

Attic and Other

U-0.15

R-6.7

U-0.12

R-8.6

U-0.30

R-3.3

Walls, Above-grade

Mass

U-0.86a

R-1.0 cia

U-0.70

R-1.3 ci

U-0.86 a

R-1.0 cia

Metal Building

U-0.41

R-2.3 + R-0.9 ci

U-0.41

R-2.3 + R-0.9 ci

U-0.64

R-2.3

Steel Framed

U-0.43

R-2.3 + R-0.9 ci

U-0.43

R-2.3 + R-0.9 ci

U-0.71

R-2.3

Wood Framed and Other

U-0.36

R-2.3 + R-0.7 ci

U-0.36

R-2.3 + R-0.7 ci

U-0.50

R-2.3

Wall, Below Grade

Below Grade Wall

C-6.47

NR

C-6.47

NR

C-6.47

NR

Floors

Mass

U-0.78

R-0.7 ci

U-0.78

R-0.7 ci

U-1.83

NR

Steel Joist

U-0.30

R-3.3

U-0.30

R-3.3

U-1.99

NR

Wood Framed and Other

U-0.29

R-3.3

U-0.29

R-3.3

U-1.60

NR

Slab-On-Grade Floors

Unheated

F-1.26

NR

F-1.26

NR

F-1.26

NR

Heated

F-1.11

R-1.3 for 300 mm
+ R-0.9 ci below

F-1.11

R-1.3 for 300 mm
+ R-0.9 ci below

F-1.77

R-1.3 for
300mm

Opaque Doors

Swinging

U-3.41

U-3.41

U-3.41

Non-Swinging

U-2.84

U-2.84

U-2.84

Assembly

Assembly

Assembly

Assembly

Assembly

Assembly

Fenestration

Max. U

Max. SHGC

Max. U

Max. SHGC

Max. U

Max. SHGC

Vertical Fenestration,0-40% of Wall

Nonmetal framing: allb

Metal fr: curtainwall/storefrontc

Metal framing: entrance doorc

Metal framing: all otherc

U-6.81

U-6.81

U-6.81

U-6.81

SHGC-0.25 all

U-6.81

U-6.81

U-6.81

SHGC-0.25 all

U-6.81

U-6.81

U-6.81

SHGC-NR all

Skylight with Curb, Glass,% of Roof

0-2.0%

Uall-4.03

SHGCall-0.19

Uall-4.03

SHGCall-0.16

Uall-11.24

SHGCall-NR

2.1-5.0%

Uall-4.03

SHGCall-0.19

Uall-4.03

SHGCall-0.16

Uall-11.24

SHGCall-NR

Skylight with Curb, Plastic,% of Roof

0-2.0%

Uall-6.36

SHGCall-0.27

Uall-6.36

SHGCall-0.27

Uall-10.79

SHGCall-NR

2.1-5.0%

Uall-6.36

SHGCall-0.27

Uall-6.36

SHGCall-0.27

Uall-10.79

SHGCall-NR

Skylight without Curb, All,% of Roof

0-2.0%

Uall-3.24

SHGCall-0.19

Uall-3.24

SHGCall-0.19

Uall-7.72

SHGCall-NR

2.1-5.0%

Uall-3.24

SHGCall-0.19

Uall-3.24

SHGCall-0.19

Uall-7.72

SHGCall-NR

a Mass walls with a heat capacity greater than 245 kJ/m2·K which are unfinished or finished only on the interior do not need to be insulated.

b Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.

c Metal framing includes metal framing with or without thermal break. The all other subcategory includes operable windows, fixed windows, and
nonentrance doors.

d Filled cavity with thermal block is as shown in Table A2.3 of Standard 90.1.

Table A-2 (supersedes Table 5.5-2 in ASHRAE/IESNA Standard 90.1)

Building Envelope Requirements For Climate Zone 2 (A,B) (SI)

Nonresidential

Residential

Semiheated

Assembly

Insulation

Assembly

Insulation

Assembly

Insulation

Opaque Elements

Max.

Min. R-Value

Max.

Min. R-Value

Max.

Min.R-Value

Roofs

Insulation Entirely above Deck

U-0.22

R-4.4 ci

U-0.22

R-4.4 ci

U-0.98

R-0.9 ci

Metal Building

U-0.23

R-3.3 + R-1.8
filled cavity w/tbd

U-0.23

R-3.3 + R-1.8
filled cavity w/tbd

U-0.37

R-3.3

Attic and Other

U-0.12

R-8.6

U-0.12

R-8.6

U-0.30

R-3.3

Walls, Above-grade

Mass

U-0.70

R-1.3 ci

U-0.59

R-1.7 ci

U-0.86 a

R-1.0 cia

Metal Building

U-0.41

R-2.3 + R-0.9 ci

U-0.30

R-2.3 + R-1.8 ci

U-0.48

R-3.3

Steel Framed

U-0.43

R-2.3 + R-0.9 ci

U-0.31

R-2.3 + R-1.8 ci

U-0.48

R-2.3 +
R-0.7 ci

Wood Framed and Other

U-0.36

R-2.3 + R-0.7 ci

U-0.36

R-2.3 + R-0.7 ci

U-0.36

R-2.3 +
R-0.7 ci

Wall, Below Grade

Below Grade Wall

C-6.47

NR

C-6.47

NR

C-6.47

NR

Floors

Mass

U-0.61

R-1.1 ci

U-0.50

R-1.5

U-1.83

NR

Steel Joist

U-0.21

R-5.3

U-0.21

R-5.3

U-0.30

R-3.3

Wood Framed and Other

U-0.19

R-5.3

U-0.15

R-5.3 + R-1.3 ci

U-0.29

R-3.3

Slab-On-Grade Floors

Unheated

F-1.26

NR

F-1.26

NR

F-1.26

NR

Heated

F-1.11

R-1.3 for 300 mm
+ R-0.9 ci below

F-1.11

R-1.3 for 300 mm +
R-0.9 ci below

F-1.77

R-1.3 for

300mm

Opaque Doors

Swinging

U-3.41

U-3.41

U-3.41

Non-Swinging

U-2.84

U-2.27

U-2.84

Assembly

Assembly

Assembly

Assembly

Assembly

Assembly

Fenestration

Max. U

Max. SHGC

Max. U

Max. SHGC

Max. U

Max. SHGC

Vertical Fenestration,0-40% of Wall

Nonmetal framing: allb

Metal fr: curtainwall/storefrontc

Metal framing: entrance doorc

Metal framing: all otherc

U-4.26

U-3.97

U-6.25

U-4.26

SHGC-0.25 all

U-4.26

U-3.97

U-6.25

U-4.26

SHGC-0.25 all

U-6.81

U-6.81

U-6.81

SHGC-NR all

Skylight with Curb, Glass,% of Roof

0-2.0%

Uall-4.03

SHGCall-0.19

Uall-4.03

SHGCall-0.16

Uall-11.24

SHGCall-NR

2.1-5.0%

Uall-4.03

SHGCall-0.19

Uall-4.03

SHGCall-0.16

Uall-11.24

SHGCall-NR

Skylight with Curb, Plastic,% of Roof

0-2.0%

Uall-6.36

SHGCall-0.27

Uall-6.36

SHGCall-0.27

Uall-10.79

SHGCall-NR

2.1-5.0%

Uall-6.36

SHGCall-0.27

Uall-6.36

SHGCall-0.27

Uall-10.79

SHGCall-NR

Skylight without Curb, All,% of Roof

0-2.0%

Uall-3.24

SHGCall-0.19

Uall-3.24

SHGCall-0.19

Uall-7.72

SHGCall-NR

2.1-5.0%

Uall-3.24

SHGCall-0.19

Uall-3.24

SHGCall-0.19

Uall-7.72

SHGCall-NR

a Mass walls with a heat capacity greater than 245 kJ/m2·K which are unfinished or finished only on the interior do not need to be insulated.

b Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.

c Metal framing includes metal framing with or without thermal break. The all other subcategory includes operable windows, fixed windows, and nonentrance doors.

d Filled cavity with thermal block is as shown in Table A2.3 of Standard 90.1.

Table A-3 (supersedes Table 5.5-3 in ASHRAE/IESNA Standard 90.1)

Building Envelope Requirements For Climate Zone 3 (A,B,C) (SI)

Nonresidential

Residential

Semiheated

Assembly

Insulation

Assembly

Insulation

Assembly

Insulation

Opaque Elements

Max.

Min. R-Value

Max.

Min. R-Value

Max.

Min.R-Value

Roofs

Insulation Entirely above Deck

U-0.22

R-4.4 ci

U-0.22

R-4.4 ci

U-0.68

R-1.3 ci

Metal Building

U-0.23

R-3.3 + R-1.8
filled cavity w/tbd

U-0.23

R-3.3 + R-1.8
filled cavity w/tbd

U-0.37

R-3.3

Attic and Other

U-0.12

R-8.6

U-0.12

R-8.6

U-0.19

R-5.3

Walls, Above-grade

Mass

U-0.59

R-1.7 ci

U-0.51

R-2.0 ci

U-0.86 a

R-1.0 cia

Metal Building

U-0.41

R-2.3 + R-0.9 ci

U-0.30

R-2.3 + R-1.8 ci

U-0.48

R-3.3

Steel Framed

U-0.43

R-2.3 + R-0.9 ci

U-0.31

R-2.3 + R-1.8 ci

U-0.48

R-2.3 +
R-0.7 ci

Wood Framed and Other

U-0.36

R-2.3 + R-0.7 ci

U-0.36

R-2.3 + R-0.7 ci

U-0.36

R-2.3 +
R-0.7 ci

Wall, Below Grade

Below Grade Wall

C-6.47

NR

C-6.47

NR

C-6.47

NR

Floors

Mass

U-0.61

R-1.1 ci

U-0.50

R-1.5 ci

U-1.83

NR

Steel Joist

U-0.21

R-5.3

U-0.21

R-5.3

U-0.30

R-3.3

Wood Framed and Other

U-0.19

R-5.3

U-0.15

R-5.3 + R-1.3 ci

U-0.29

R-3.3

Slab-On-Grade Floors

Unheated

F-1.26

NR

F-1.26

NR

F-1.26

NR

Heated

F-1.11

R-1.3 for 300 mm
+ R-0.9 ci below

F-1.11

R-1.3 for 300 mm +
R-0.9 ci below

F-1.77

R-1.3 for
300mm

Opaque Doors

Swinging

U-3.41

U-3.41

U-3.41

Non-Swinging

U-2.84

U-2.27

U-2.84

Assembly

Assembly

Assembly

Assembly

Assembly

Assembly

Fenestration

Max. U

Max. SHGC

Max. U

Max. SHGC

Max. U

Max. SHGC

Vertical Fenestration,0-40% of Wall

Nonmetal framing: allb

Metal fr: curtainwall/storefrontc

Metal framing: entrance doorc

Metal framing: all otherc

U-2.56

U-2.84

U-4.54

U-3.12

SHGC-0.25 all

U-2.56

U-2.84

U-4.54

U-3.12

SHGC-0.25 all

U-3.12

U-3.41

U-4.54

U-3.69

SHGC-NR all

Skylight with Curb, Glass,% of Roof

0-2.0%

Uall-3.92

SHGCall-0.19

Uall-3.92

SHGCall-0.16

Uall-11.24

SHGCall-NR

2.1-5.0%

Uall-3.92

SHGCall-0.19

Uall-3.92

SHGCall-0.16

Uall-11.24

SHGCall-NR

Skylight with Curb, Plastic,% of Roof

0-2.0%

Uall-3.92

SHGCall-0.27

Uall-3.92

SHGCall-0.27

Uall-10.79

SHGCall-NR

2.1-5.0%

Uall-3.92

SHGCall-0.27

Uall-3.92

SHGCall-0.27

Uall-10.79

SHGCall-NR

Skylight without Curb, All,% of Roof

0-2.0%

Uall-2.56

SHGCall-0.19

Uall-2.56

SHGCall-0.19

Uall-7.72

SHGCall-NR

2.1-5.0%

Uall-2.56

SHGCall-0.19

Uall-2.56

SHGCall-0.19

Uall-7.72

SHGCall-NR

a Mass walls with a heat capacity greater than 245 kJ/m2·K which are unfinished or finished only on the interior do not need to be insulated.

b Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.

c Metal framing includes metal framing with or without thermal break. The all other subcategory includes operable windows, fixed windows, and nonentrance doors.

d Filled cavity with thermal block is as shown in Table A2.3 of Standard 90.1.

Table A-4 (supersedes Table 5.5-4 in ASHRAE/IESNA Standard 90.1)

Building Envelope Requirements For Climate Zone 4 (A,B,C) (SI)

Nonresidential

Residential

Semiheated

Assembly

Insulation

Assembly

Insulation

Assembly

Insulation

Opaque Elements

Max.

Min. R-Value

Max.

Min. R-Value

Max.

Min.R-Value

Roofs

Insulation Entirely above Deck

U-0.22

R-4.4 ci

U-0.22

R-4.4 ci

U-0.68

R-1.3 ci

Metal Building

U-0.23

R-3.3 + R-1.8
filled cavity w/tbd

U-0.23

R-3.3 + R-1.8
filled cavity w/tbd

U-0.37

R-3.3

Attic and Other

U-0.12

R-8.6

U-0.12

R-8.6

U-0.19

R-5.3

Walls, Above-grade

Mass

U-0.51

R-2.0 ci

U-0.45

R-2.3 ci

U-0.86 a

R-1.0 cia

Metal Building

U-0.30

R-2.3 + R-1.8 ci

U-0.30

R-2.3 + R-1.8 ci

U-0.48

R-3.3

Steel Framed

U-0.31

R-2.3 + R-1.8 ci

U-0.31

R-2.3 + R-1.8 ci

U-0.48

R-2.3 +
R-0.7 ci

Wood Framed and Other

U-0.36

R-2.3 + R-0.7 ci

U-0.29

R-2.3 + R-1.3 ci

U-0.36

R-2.3 +
R-0.7 ci

Wall, Below Grade

Below Grade Wall

C-0.68

R-1.3 ci

C-0.52

R-1.8 ci

C-0.68

R-1.3 ci

Floors

Mass

U-0.42

R-1.8 ci

U-0.36

R-2.2 ci

U-0.61

R-1.1 ci

Steel Joist

U-0.18

R-6.7

U-0.18

R-6.7

U-0.30

R-3.3

Wood Framed and Other

U-0.15

R-5.3 + R-1.3 ci

U-0.15

R-5.3 + R-1.3 ci

U-0.29

R-3.3

Slab-On-Grade Floors

Unheated

F-0.93

R-1.8 for 600 mm

F-0.90

R-2.6 for 600 mm

F-0.93

R-1.8 for 600
mm

Heated

F-0.95

R-1.8 for 600 mm +
R-0.9 ci below

F-0.95

R-1.8 for 600 mm
+ R-0.9 ci below

F-1.64

R-1.3 for 600
mm

Opaque Doors

Swinging

U-3.41

U-3.41

U-3.41

Non-Swinging

U-2.27

U-2.27

U-2.84

Assembly

Assembly

Assembly

Assembly

Assembly

Assembly

Fenestration

Max. U

Max. SHGC

Max. U

Max. SHGC

Max. U

Max. SHGC

Vertical Fenestration,0-40% of Wall

Nonmetal framing: allb

Metal fr: curtainwall/storefrontc

Metal framing: entrance doorc

Metal framing: all otherc

U-1.70

U-2.27

U-4.26

U-2.56

SHGC-0.35 all

U-1.70

U-2.27

U-4.26

U-2.56

SHGC-0.40 all

U-3.12

U-3.41

U-4.54

U-3.69

SHGC-NR all

Skylight with Curb, Glass,% of Roof

0-2.0%

Uall-3.92

SHGCall-0.32

Uall-3.92

SHGCall-0.19

Uall-11.24

SHGCall-NR

2.1-5.0%

Uall-3.92

SHGCall-0.32

Uall-3.92

SHGCall-0.19

Uall-11.24

SHGCall-NR

Skylight with Curb, Plastic,% of Roof

0-2.0%

Uall-3.92

SHGCall-0.34

Uall-3.92

SHGCall-0.27

Uall-10.79

SHGCall-NR

2.1-5.0%

Uall-3.92

SHGCall-0.34

Uall-3.92

SHGCall-0.27

Uall-10.79

SHGCall-NR

Skylight without Curb, All,% of Roof

0-2.0%

Uall-2.56

SHGCall-0.32

Uall-2.56

SHGCall-0.19

Uall-7.72

SHGCall-NR

2.1-5.0%

Uall-2.56

SHGCall-0.32

Uall-2.56

SHGCall-0.19

Uall-7.72

SHGCall-NR

a Mass walls with a heat capacity greater than 245 kJ/m2·K which are unfinished or finished only on the interior do not need to be insulated.

b Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.

c Metal framing includes metal framing with or without thermal break. The all other subcategory includes operable windows, fixed windows, and nonentrance doors.

d Filled cavity with thermal block is as shown in Table A2.3 of Standard 90.1.

Table A-5 (supersedes Table 5.5-5 in ASHRAE/IESNA Standard 90.1)

Building Envelope Requirements For Climate Zone 5 (A,B,C) (SI)

Nonresidential

Residential

Semiheated

Assembly

Insulation

Assembly

Insulation

Assembly

Insulation

Opaque Elements

Max.

Min. R-Value

Max.

Min. R-Value

Max.

Min.R-Value

Roofs

Insulation Entirely above Deck

U-0.22

R-4.4 ci

U-0.22

R-4.4 ci

U-0.53

R-1.8 ci

Metal Building

U-0.23

R-3.3 + R-1.8
filled cavity w/tbd

U-0.23

R-3.3 + R-1.8
filled cavity w/tbd

U-0.37

R-3.3

Attic and Other

U-0.12

R-8.6

U-0.12

R-8.6

U-0.19

R-5.3

Walls, Above-grade

Mass

U-0.45

R-2.3 ci

U-0.40

R-2.7 ci

U-0.70

R-1.3 ci

Metal Building

U-0.30

R-2.3 + R-1.8 ci

U-0.30

R-2.3 + R-1.8 ci

U-0.48

R-3.3

Steel Framed

U-0.31

R-2.3 + R-1.8 ci

U-0.31

R-2.3 + R-1.8 ci

U-0.48

R-2.3 +
R-0.7 ci

Wood Framed and Other

U-0.29

R-2.3 + R-1.3 ci

U-0.26

R-2.3 + R-1.8 ci

U-0.36

R-2.3 +
R-0.7 ci

Wall, Below Grade

Below Grade Wall

C-0.52

R-1.8 ci

C-0.52

R-1.8 ci

C-0.68

R-1.3 ci

Floors

Mass

U-0.36

R-2.2 ci

U-0.32

R-2.6 ci

U-0.61

R-1.1 ci

Steel Joist

U-0.18

R-6.7

U-0.18

R-6.7

U-0.21

R-5.3

Wood Framed and Other

U-0.15

R-5.3 + R-1.3 ci

U-0.15

R-5.3 + R-1.3 ci

U-0.19

R-5.3

Slab-On-Grade Floors

Unheated

F-0.93

R-1.8 for 600 mm

F-0.90

R-2.6 for 600 mm

F-0.93

R-1.8 for 600
mm

Heated

F-0.76

R-2.6 for 900 mm
+ R-0.9 ci below

F-0.76

R-2.6 for 900 mm
+ R-0.9 ci below

F-1.56

R-1.8 for 600
mm

Opaque Doors

Swinging

U-2.27

U-2.27

U-3.41

Non-Swinging

U-2.27

U-2.27

U-2.84

Assembly

Assembly

Assembly

Assembly

Assembly

Assembly

Fenestration

Max. U

Max. SHGC

Max. U

Max. SHGC

Max. U

Max. SHGC

Vertical Fenestration,0-40% of Wall

Nonmetal framing: allb

Metal fr: curtainwall/storefrontc

Metal framing: entrance doorc

Metal framing: all otherc

U-1.42

U-1.99

U-3.97

U-2.56

SHGC-0.35 all

U-1.42

U-1.99

U-3.97

U-2.56

SHGC-0.40 all

U-3.12

U-3.41

U-4.54

U-3.69

SHGC-NR all

Skylight with Curb, Glass,% of Roof

0-2.0%

Uall-3.80

SHGCall-0.36

Uall-3.80

SHGCall-0.36

Uall-11.24

SHGCall-NR

2.1-5.0%

Uall-3.80

SHGCall-0.36

Uall-3.80

SHGCall-0.36

Uall-11.24

SHGCall-NR

Skylight with Curb, Plastic,% of Roof

0-2.0%

Uall-3.92

SHGCall-0.34

Uall-3.92

SHGCall-0.34

Uall-10.79

SHGCall-NR

2.1-5.0%

Uall-3.92

SHGCall-0.34

Uall-3.92

SHGCall-0.34

Uall-10.79

SHGCall-NR

Skylight without Curb, All,% of Roof

0-2.0%

Uall-2.56

SHGCall-0.36

Uall-2.56

SHGCall-0.36

Uall-7.72

SHGCall-NR

2.1-5.0%

Uall-2.56

SHGCall-0.36

Uall-2.56

SHGCall-0.36

Uall-7.72

SHGCall-NR

a Mass walls with a heat capacity greater than 245 kJ/m2·K which are unfinished or finished only on the interior do not need to be insulated.

b Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.

c Metal framing includes metal framing with or without thermal break. The all other subcategory includes operable windows, fixed windows, and nonentrance doors.

d Filled cavity with thermal block is as shown in Table A2.3 of Standard 90.1.

Table A-6 (supersedes Table 5.5-6 in ASHRAE/IESNA Standard 90.1)

Building Envelope Requirements For Climate Zone 6 (A,B) (SI)

Nonresidential

Residential

Semiheated

Assembly

Insulation

Assembly

Insulation

Assembly

Insulation

Opaque Elements

Max.

Min. R-Value

Max.

Min. R-Value

Max.

Min.R-Value

Roofs

Insulation Entirely above Deck

U-0.18

R-5.3 ci

U-0.18

R-5.3 ci

U-0.36

R-2.6 ci

Metal Building

U-0.18

R-5.3 + R-1.1 ci,
filled cavity w/tbd

U-0.18

R-5.3 + R-1.1 ci,
filled cavity w/tbd

U-0.37

R-3.3

Attic and Other

U-0.12

R-8.6

U-0.12

R-8.6

U-0.15

R-6.7

Walls, Above-grade

Mass

U-0.40

R-2.7 ci

U-0.34

R-3.5 ci

U-0.59

R-1.7 ci

Metal Building

U-0.30

R-2.3 + R-1.8 ci

U-0.30

R-2.3 + R-1.8 ci

U-0.48

R-3.3

Steel Framed

U-0.31

R-2.3 + R-1.8 ci

U-0.31

R-2.3 + R-1.8 ci

U-0.48

R-2.3 +
R-0.7 ci

Wood Framed and Other

U-0.26

R-2.3 + R-1.8 ci

U-0.26

R-2.3 + R-1.8 ci

U-0.36

R-2.3 +
R-0.7 ci

Wall, Below Grade

Below Grade Wall

C-0.52

R-1.8 ci

C-0.52

R-1.8 ci

C-0.68

R-1.3 ci

Floors

Mass

U-0.32

R-2.6 ci

U-0.29

R-2.9 ci

U-0.61

R-1.1 ci

Steel Joist

U-0.18

R-6.7

U-0.13

R-6.7 + R-2.2 ci

U-0.21

R-5.3

Wood Framed and Other

U-0.15

R-5.3 + R-1.3 ci

U-0.15

R-5.3 + R-1.3 ci

U-0.19

R-5.3

Slab-On-Grade Floors

Unheated

F-0.90

R-2.6 for 600 mm

F-0.88

R-3.5 for 600 mm

F-0.93

R-1.8 for 600
mm

Heated

F-0.76

R-2.6 for 900 mm
+ R-0.9 ci below

F-0.76

R-2.6 for 900 mm
+ R-0.9 ci below

F-1.56

R-1.8 for 600
mm

Opaque Doors

Swinging

U-2.27

U-2.27

U-3.41

Non-Swinging

U-2.27

U-2.27

U-2.84

Assembly

Assembly

Assembly

Assembly

Assembly

Assembly

Fenestration

Max. U

Max. SHGC

Max. U

Max. SHGC

Max. U

Max. SHGC

Vertical Fenestration,0-40% of Wall

Nonmetal framing: allb

Metal fr: curtainwall/storefrontc

Metal framing: entrance doorc

Metal framing: all otherc

U-1.42

U-1.99

U-3.97

U-2.56

SHGC-0.40 all

U-1.42

U-1.99

U-3.97

U-2.56

SHGC-0.40 all

U-2.56

U-2.84

U-4.54

U-3.12

SHGC-NR all

Skylight with Curb, Glass,% of Roof

0-2.0%

Uall-3.80

SHGCall-0.46

Uall-3.80

SHGCall-0.46

Uall-11.24

SHGCall-NR

2.1-5.0%

Uall-3.80

SHGCall-0.46

Uall-3.80

SHGCall-0.46

Uall-11.24

SHGCall-NR

Skylight with Curb, Plastic,% of Roof

0-2.0%

Uall-3.92

SHGCall-0.49

Uall-3.92

SHGCall-0.49

Uall-10.79

SHGCall-NR

2.1-5.0%

Uall-3.92

SHGCall-0.49

Uall-3.92

SHGCall-0.49

Uall-10.79

SHGCall-NR

Skylight without Curb, All,% of Roof

0-2.0%

Uall-2.56

SHGCall-0.46

Uall-2.56

SHGCall-0.39

Uall-7.72

SHGCall-NR

2.1-5.0%

Uall-2.56

SHGCall-0.46

Uall-2.56

SHGCall-0.39

Uall-7.72

SHGCall-NR

a Mass walls with a heat capacity greater than 245 kJ/m2·K which are unfinished or finished only on the interior do not need to be insulated.

b Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.

c Metal framing includes metal framing with or without thermal break. The all other subcategory includes operable windows, fixed windows, and nonentrance doors.

d Filled cavity with thermal block is as shown in Table A2.3 of Standard 90.1.

Table A-7 (supersedes Table 5.5-7 in ASHRAE/IESNA Standard 90.1)

Building Envelope Requirements For Climate Zone 7 (SI)

Nonresidential

Residential

Semiheated

Assembly

Assembly

Assembly

Assembly

Assembly

Assembly

Opaque Elements

Max. U

Max. SHGC

Max. U

Max. SHGC

Max. U

Max. SHGC

Roofs

Insulation Entirely above Deck

U-0.16

R-6.2 ci

U-0.16

R-6.2 ci

U-0.36

R-2.6 ci

Metal Building

U-0.16

R-5.3 + R-1.8 ci,
filled cavity w/tbd

U-0.16

R-5.3 + R-1.8 ci,
filled cavity w/tbd

U-0.37

R-3.3

Attic and Other

U-0.10

R-10.6

U-0.10

R-10.6

U-0.15

R-6.7

Walls, Above-grade

Mass

U-0.34

R-3.5 ci

U-0.34

R-3.5 ci

U-0.51

R-2.0 ci

Metal Building

U-0.30

R-2.3 + R-1.8 ci

U-0.21

R-2.3 + R-3.3 ci

U-0.48

R-3.3

Steel Framed

U-0.31

R-2.3 + R-1.8 ci

U-0.21

R-2.3 + R-3.3 ci

U-0.48

R-2.3 + R-0.7 ci

Wood Framed and Other

U-0.26

R-2.3 + R-1.8 ci

U-0.26

R-2.3 + R-1.8 ci

U-0.36

R-2.3 + R-0.7 ci

Wall, Below Grade

Below Grade Wall

C-0.52

R-1.8 ci

C-0.42

R-2.2 ci

C-0.68

R-1.3 ci

Floors

Mass

U-0.25

R-3.5 ci

U-0.25

R-3.5 ci

U-0.50

R-1.5 ci

Steel Joist

U-0.18

R-6.7

U-0.13

R-6.7 + R-2.2 ci

U-0.21

R-5.3

Wood Framed and Other

U-0.15

R-5.3 + R-1.3 ci

U-0.15

R-5.3 + R-1.3 ci

U-0.19

R-5.3

Slab-On-Grade Floors

Unheated

F-0.52

R-2.6 for 600 mm
+ R-0.9 ci below

F-0.52

R-2.6 for 600 mm +
R-0.9 ci below

F-0.93

R-1.8 for 600
mm

Heated

F-0.65

R-3.5 for 900 mm
+ R-0.9 ci below

F-0.65

R-3.5 for 900 mm +
R-0.9 ci below

F-1.19

R-3.5 for1200
mm

Opaque Doors

Swinging

U-2.27

U-2.27

U-3.41

Non-Swinging

U-2.27

U-2.27

U-2.84

Assembly

Assembly Max.

Assembly

Assembly Max.

Assembly

Assembly Max.

Fenestration

Max. U

SHGC

Max. U

SHGC

Max. U

SHGC

Vertical Fenestration,0-40% of Wall

Nonmetal framing: allb

Metal fr: curtainwall/storefrontc

Metal framing: entrance doorc

Metal framing: all otherc

U-1.42

U-1.70

U-3.97

U-1.99

SHGC-0.45 all

U-1.42

U-1.70

U-3.97

U-1.99

SHGC-NR all

U-2.56

U-2.84

U-4.54

U-3.12

SHGC-NR all

Skylight with Curb, Glass,% of Roof

0-2.0%

Uall-3.80

SHGCall-0.46

Uall-3.80

SHGCall-0.46

Uall-11.24

SHGCall-NR

2.1-5.0%

Uall-3.80

SHGCall-0.46

Uall-3.80

SHGCall-0.46

Uall-11.24

SHGCall-NR

Skylight with Curb, Plastic,% of Roof

0-2.0%

Uall-3.92

SHGCall-0.50

Uall-3.92

SHGCall-0.50

Uall-10.79

SHGCall-NR

2.1-5.0%

Uall-3.92

SHGCall-0.50

Uall-3.92

SHGCall-0.50

Uall-10.79

SHGCall-NR

Skylight without Curb, All,% of Roof

0-2.0%

Uall-2.56

SHGCall-0.46

Uall-2.56

SHGCall-0.46

Uall-7.72

SHGCall-NR

2.1-5.0%

Uall-2.56

SHGCall-0.46

Uall-2.56

SHGCall-0.46

Uall-7.72

SHGCall-NR

a Mass walls with a heat capacity greater than 245 kJ/m2·K which are unfinished or finished only on the interior do not need to be insulated.

b Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.

c Metal framing includes metal framing with or without thermal break. The all other subcategory includes operable windows, fixed windows, and nonentrance doors.

d Filled cavity with thermal block is as shown in Table A2.3 of Standard 90.1.

Table A-8 (supersedes Table 5.5-8 in ASHRAE/IESNA Standard 90.1)

Building Envelope Requirements For Climate Zone 8 (SI)

Nonresidential

Residential

Semiheated

Assembly

Insulation

Assembly

Insulation

Assembly

Insulation

Opaque Elements

Max.

Min. R-Value

Max.

Min. R-Value

Max.

Min.R-Value

Roofs

Insulation Entirely above Deck

U-0.16

R-6.2 ci

U-0.16

R-6.2 ci

U-0.27

R-3.5 ci

Metal Building

U-0.16

R-5.3 + R-1.8 ci,
filled cavity w/tbd

U-0.16

R-5.3 + R-1.8 ci,
filled cavity w/tbd

U-0.28

R-2.3 + R-3.3

Attic and Other

U-0.10

R-10.6

U-0.10

R-10.6

U-0.15

R-6.7

Walls, Above-grade

Mass

U-0.34

R-3.5 ci

U-0.24

R-5.5 ci

U-0.45

R-2.3 ci

Metal Building

U-0.30

R-2.3 + R-1.8 ci

U-0.18

R-2.3 + R-3.9 ci

U-0.35

R-2.3 + R-1.3 ci

Steel Framed

U-0.31

R-2.3 + R-1.8 ci

U-0.19

R-2.3 + R-3.9 ci

U-0.37

R-2.3 + R-1.3 ci

Wood Framed and Other

U-0.26

R-2.3 + R-1.8 ci

U-0.18

R-2.3 + R-3.3 ci

U-0.36

R-2.3 + R-0.7 ci

Wall, Below Grade

Below Grade Wall

C-0.52

R-1.8 ci

C-0.36

R-2.6 ci

C-0.68

R-1.3 ci

Floors

Mass

U-0.25

R-3.5 ci

U-0.25

R-3.5 ci

U-0.36

R-2.2 ci

Steel Joist

U-0.13

R-6.7 + R-2.2 ci

U-0.13

R-6.7 + R-2.2 ci

U-0.21

R-5.3

Wood Framed and Other

U-0.15

R-5.3 + R-1.3 ci

U-0.15

R-5.3 + R-1.3 ci

U-0.15

R-5.3 + R-1.3 ci

Slab-On-Grade Floors

Unheated

F-0.52

R-2.6 for 600 mm
+ R-0.9 ci below

F-0.52

R-2.6 for 600 mm +
R-0.9 ci below

F-0.93

R-1.8 for 600
mm

Heated

F-0.65

R-3.5 for 900 mm
+ R-0.9 ci below

F-0.65

R-3.5 for 900 mm +
R-0.9 ci below

F-1.19

R-3.5 for1200
mm

Opaque Doors

Swinging

U-2.27

U-2.27

U-2.27

Non-Swinging

U-2.27

U-2.27

U-2.27

Assembly

Assembly

Assembly

Assembly

Assembly

Assembly

Fenestration

Max. U

Max. SHGC

Max. U

Max. SHGC

Max. U

Max. SHGC

Vertical Fenestration,0-40% of Wall

Nonmetal framing: allb

Metal fr: curtainwall/storefrontc

Metal framing: entrance doorc

Metal framing: all otherc

U-1.42

U-1.70

U-3.97

U-1.99

SHGC-0.45 all

U-1.42

U-1.70

U-3.97

U-1.99

SHGC-NR all

U-2.56

U-2.84

U-4.54

U-3.12

SHGC-NR all

Skylight with Curb, Glass,% of Roof

0-2.0%

Uall-3.29

SHGCall-NR

Uall-3.29

SHGCall-NR

Uall-7.38

SHGCall-NR

2.1-5.0%

Uall-3.29

SHGCall-NR

Uall-3.29

SHGCall-NR

Uall-7.38

SHGCall-NR

Skylight with Curb, Plastic,% of Roof

0-2.0%

Uall-3.29

SHGCall-NR

Uall-3.29

SHGCall-NR

Uall-6.25

SHGCall-NR

2.1-5.0%

Uall-3.29

SHGCall-NR

Uall-3.29

SHGCall-NR

Uall-6.25

SHGCall-NR

Skylight without Curb, All,% of Roof

0-2.0%

Uall-2.56

SHGCall-NR

Uall-2.56

SHGCall-NR

Uall-4.60

SHGCall-NR

2.1-5.0%

Uall-2.56

SHGCall-NR

Uall-2.56

SHGCall-NR

Uall-4.60

SHGCall-NR

a Mass walls with a heat capacity greater than 245 kJ/m2·K which are unfinished or finished only on the interior do not need to be insulated.

b Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.

c Metal framing includes metal framing with or without thermal break. The all other subcategory includes operable windows, fixed windows, and nonentrance doors.

d Filled cavity with thermal block is as shown in Table A2.3 of Standard 90.1.

TABLE A-9 (supersedes Table A2.4.2 in ASHRAE/IESNA Standard 90.1)

Single-Rafter Roof Requirements (SI)

Climate Zone

Minimum Insulation R-Value or Maximum Assembly U-Factor

Nonresidential

Residential

Semiheated

1

R-6.7

U-0.165

R-6.7 + R-1.8 ci

U-0.114

R-3.3

U-0.312

2

R-6.7 + R-1.8 ci

U-0.114

R-6.7 + R-1.8 ci

U-0.114

R-3.3

U-0.312

3, 4, 5

R-6.7 + R-1.8 ci

U-0.114

R-6.7 + R-1.8 ci

U-0.114

R-5.3

U-0.204

6

R-6.7 + R-1.8 ci

U-0.114

R-6.7 + R-1.8 ci

U-0.114

R-6.7

U-0.165

7, 8

R-6.7 + R-2.6 ci

U-0.102

R-6.7 + R-2.6 ci

U-0.102

R-6.7

U-0.165

Table A-1 (supersedes Table 5.5-1 in ASHRAE/IESNA Standard 90.1)

Building Envelope Requirements For Climate Zone 1 (A,B) (I-P)

Nonresidential

Residential

Semiheated

Assembly

Insulation

Assembly

Insulation

Assembly

Insulation

Opaque Elements

Max.

Min. R-Value

Max.

Min. R-Value

Max.

Min.R-Value

Roofs

Insulation Entirely above Deck

U-0.048

R-20.0 ci

U-0.039

R-25.0 ci

U-0.173

R-5.0 ci

Metal Building

U-0.049

R-13.0 + R-19.0

U-0.041

R-19.0 + R-10.0
filled cavity w/tbd

U-0.083

R-13.0

Attic and Other

U-0.027

R-38.0

U-0.021

R-49.0

U-0.053

R-19.0

Walls, Above-grade

Mass

U-0.151a

R-5.7 cia

U-0.123

R-7.6 ci

U-0.151a

R-5.7 cia

Metal Building

U-0.072

R-13.0 + R-5.0 ci

U-0.072

R-13.0 + R-5.0 ci

U-0.113

R-13.0

Steel Framed

U-0.077

R-13.0 + R-5.0 ci

U-0.077

R-13.0 + R-5.0 ci

U-0.124

R-13.0

Wood Framed and Other

U-0.064

R-13.0 + R-3.8 ci

U-0.064

R-13.0 + R-3.8 ci

U-0.089

R-13.0

Wall, Below Grade

Below Grade Wall

C-1.140

NR

C-1.140

NR

C-1.140

NR

Floors

Mass

U-0.137

R-4.2 ci

U-0.137

R-4.2 ci

U-0.322

NR

Steel Joist

U-0.052

R-19.0

U-0.052

R-19.0

U-0.350

NR

Wood Framed and Other

U-0.051

R-19.0

U-0.051

R-19.0

U-0.282

NR

Slab-On-Grade Floors

Unheated

F-0.730

NR

F-0.730

NR

F-0.730

NR

Heated

F-0.640

R-7.5 for 12 in. +
R-5 ci below

F-0.640

R-7.5 for 12 in. +
R-5 ci below

F-1.020

R-7.5 for
12 in.

Opaque Doors

Swinging

U-0.600

U-0.600

U-0.600

Non-Swinging

U-0.500

U-0.500

U-0.500

Assembly

Assembly

Assembly

Assembly

Assembly

Assembly

Fenestration

Max. U

Max. SHGC

Max. U

Max. SHGC

Max. U

Max. SHGC

Vertical Fenestration,0-40% of Wall

Nonmetal framing: allb

Metal fr: curtainwall/storefrontc

Metal framing: entrance doorc

Metal framing: all otherc

U-1.20

U-1.20

U-1.20

U-1.20

SHGC-0.25 all

U-1.20

U-1.20

U-1.20

SHGC-0.25 all

U-1.20

U-1.20

U-1.20

SHGC-NR all

Skylight with Curb, Glass,% of
Roof

0-2.0%

Uall-0.71

SHGCall-0.19

Uall-0.71

SHGCall-0.16

Uall-1.98

SHGCall-NR

2.1-5.0%

Uall-0.71

SHGCall-0.19

Uall-0.71

SHGCall-0.16

Uall-1.98

SHGCall-NR

Skylight with Curb, Plastic,% of Roof

0-2.0%

Uall-1.12

SHGCall-0.27

Uall-1.12

SHGCall-0.27

Uall-1.90

SHGCall-NR

2.1-5.0%

Uall-1.12

SHGCall-0.27

Uall-1.12

SHGCall-0.27

Uall-1.90

SHGCall-NR

Skylight without Curb, All,% of Roof

0-2.0%

Uall-0.57

SHGCall-0.19

Uall-0.57

SHGCall-0.19

Uall-1.36

SHGCall-NR

2.1-5.0%

Uall-0.57

SHGCall-0.19

Uall-0.57

SHGCall-0.19

Uall-1.36

SHGCall-NR

a Mass walls with a heat capacity greater than 12 Btu/ft2·ºF which are unfinished or finished only on the interior do not need to be insulated.

b Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.

c Metal framing includes metal framing with or without thermal break. The all other subcategory includes operable windows, fixed windows, and nonentrance doors.

d Filled cavity with thermal block is as shown in Table A2.3 of Standard 90.1.

Table A-2 (supersedes Table 5.5-2 in ASHRAE/IESNA Standard 90.1)

Building Envelope Requirements For Climate Zone 2 (A,B) (I-P)

Nonresidential

Residential

Semiheated

Assembly

Insulation

Assembly

Insulation

Assembly

Insulation

Opaque Elements

Max.

Min. R-Value

Max.

Min. R-Value

Max.

Min.R-Value

Roofs

Insulation Entirely above Deck

U-0.039

R-25.0 ci

U-0.039

R-25.0 ci

U-0.173

R-5.0 ci

Metal Building

U-0.041

R-19.0 + R-10.0
filled cavity w/tbd

U-0.041

R-19.0 + R-10.0
filled cavity w/tbd

U-0.065

R-19.0

Attic and Other

U-0.021

R-49.0

U-0.021

R-49.0

U-0.053

R-19.0

Walls, Above-grade

Mass

U-0.123

R-7.6 ci

U-0.104

R-9.5 ci

U-0.151a

R-5.7 cia

Metal Building

U-0.072

R-13.0 + R-5.0 ci

U-0.053

R-13.0 + R-10.0 ci

U-0.084

R-19.0

Steel Framed

U-0.077

R-13.0 + R-5.0 ci

U-0.055

R-13.0 + R-10.0 ci

U-0.084

R-13.0 +
R-3.8 ci

Wood Framed and Other

U-0.064

R-13.0 + R-3.8 ci

U-0.064

R-13.0 + R-3.8 ci

U-0.064

R-13.0 +
R-3.8 ci

Wall, Below Grade

Below Grade Wall

C-1.140

NR

C-1.140

NR

C-1.140

NR

Floors

Mass

U-0.107

R-6.3 ci

U-0.087

R-8.3 ci

U-0.322

NR

Steel Joist

U-0.038

R-30.0

U-0.038

R-30.0

U-0.052

R-19.0

Wood Framed and Other

U-0.033

R-30.0

U-0.026

R-30.0 + R-7.5 ci

U-0.051

R-19.0

Slab-On-Grade Floors

Unheated

F-0.730

NR

F-0.730

NR

F-0.730

NR

Heated

F-0.640

R-7.5 for 12 in. +
R-5 ci below

F-0.640

R-7.5 for 12 in. +
R-5 ci below

F-1.020

R-7.5 for
12 in.

Opaque Doors

Swinging

U-0.600

U-0.600

U-0.600

Non-Swinging

U-0.500

U-0.400

U-0.500

Assembly

Assembly

Assembly

Assembly

Assembly

Assembly

Fenestration

Max. U

Max. SHGC

Max. U

Max. SHGC

Max. U

Max. SHGC

Vertical Fenestration,0-40% of Wall

Nonmetal framing: allb

Metal fr: curtainwall/storefrontc

Metal framing: entrance doorc

Metal framing: all otherc

U-0.75

U-0.70

U-1.10

U-0.75

SHGC-0.25 all

U-0.75

U-0.70

U-1.10

U-0.75

SHGC-0.25 all

U-1.20

U-1.20

U-1.20

U-1.20

SHGC-NR all

Skylight with Curb, Glass,% of Roof

0-2.0%

Uall-0.71

SHGCall-0.19

Uall-0.71

SHGCall-0.16

Uall-1.98

SHGCall-NR

2.1-5.0%

Uall-0.71

SHGCall-0.19

Uall-0.71

SHGCall-0.16

Uall-1.98

SHGCall-NR

Skylight with Curb, Plastic,% of Roof

0-2.0%

Uall-1.12

SHGCall-0.27

Uall-1.12

SHGCall-0.27

Uall-1.90

SHGCall-NR

2.1-5.0%

Uall-1.12

SHGCall-0.27

Uall-1.12

SHGCall-0.27

Uall-1.90

SHGCall-NR

Skylight without Curb, All,% of Roof

0-2.0%

Uall-0.57

SHGCall-0.19

Uall-0.57

SHGCall-0.19

Uall-1.36

SHGCall-NR

2.1-5.0%

Uall-0.57

SHGCall-0.19

Uall-0.57

SHGCall-0.19

Uall-1.36

SHGCall-NR

a Mass walls with a heat capacity greater than 12 Btu/ft2·ºF which are unfinished or finished only on the interior do not need to be insulated.

b Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.

c Metal framing includes metal framing with or without thermal break. The all other subcategory includes operable windows, fixed windows, and nonentrance doors.

d Filled cavity with thermal block is as shown in Table A2.3 of Standard 90.1.

Table A-3 (supersedes Table 5.5-3 in ASHRAE/IESNA Standard 90.1)

Building Envelope Requirements For Climate Zone 3 (A,B,C) (I-P)

Nonresidential

Residential

Semiheated

Assembly

Insulation

Assembly

Insulation

Assembly

Insulation

Opaque Elements

Max.

Min. R-Value

Max.

Min. R-Value

Max.

Min.R-Value

Roofs

Insulation Entirely above Deck

U-0.039

R-25.0 ci

U-0.039

R-25.0 ci

U-0.119

R-7.6 ci

Metal Building

U-0.041

R-19.0 + R-10.0
filled cavity w/tbd

U-0.041

R-19.0 + R-10.0
filled cavity w/tbd

U-0.065

R-19.0

Attic and Other

U-0.021

R-49.0

U-0.021

R-49.0

U-0.034

R-30.0

Walls, Above-grade

Mass

U-0.104

R-9.5 ci

U-0.090

R-11.4 ci

U-0.151a

R-5.7 cia

Metal Building

U-0.072

R-13.0 + R-5.0 ci

U-0.053

R-13.0 + R-10.0 ci

U-0.084

R-19.0

Steel Framed

U-0.077

R-13.0 + R-5.0 ci

U-0.055

R-13.0 + R-10.0 ci

U-0.084

R-13.0 +
R-3.8 ci

Wood Framed and Other

U-0.064

R-13.0 + R-3.8 ci

U-0.064

R-13.0 + R-3.8 ci

U-0.064

R-13.0 +
R-3.8 ci

Wall, Below Grade

Below Grade Wall

C-1.140

NR

C-1.140

NR

C-1.140

NR

Floors

Mass

U-0.107

R-6.3 ci

U-0.087

R-8.3 ci

U-0.332

NR

Steel Joist

U-0.038

R-30.0

U-0.038

R-30.0

U-0.052

R-19.0

Wood Framed and Other

U-0.033

R-30.0

U-0.026

R-30.0 + R-7.5 ci

U-0.051

R-19.0

Slab-On-Grade Floors

Unheated

F-0.730

NR

F-0.730

NR

F-0.730

NR

Heated

F-0.640

R-7.5 for 12 in. +
R-5 ci below

F-0.640

R-7.5 for 12 in. +
R-5 ci below

F-1.020

R-7.5 for
12 in.

Opaque Doors

Swinging

U-0.600

U-0.600

U-0.600

Non-Swinging

U-0.500

U-0.400

U-0.500

Assembly

Assembly

Assembly

Assembly

Assembly

Assembly

Fenestration

Max. U

Max. SHGC

Max. U

Max. SHGC

Max. U

Max. SHGC

Vertical Fenestration,0-40% of Wall

Nonmetal framing: allb

Metal fr: curtainwall/storefrontc

Metal framing: entrance doorc

Metal framing: all otherc

U-0.45

U-0.50

U-0.80

U-0.55

SHGC-0.25 all

U-0.45

U-0.50

U-0.80

U-0.55

SHGC-0.25 all

U-0.55

U-0.60

U-0.80

U-0.65

SHGC-NR all

Skylight with Curb, Glass,% of Roof

0-2.0%

Uall-0.69

SHGCall-0.19

Uall-0.69

SHGCall-0.16

Uall-1.98

SHGCall-NR

2.1-5.0%

Uall-0.69

SHGCall-0.19

Uall-0.69

SHGCall-0.16

Uall-1.98

SHGCall-NR

Skylight with Curb, Plastic,% of Roof

0-2.0%

Uall-0.69

SHGCall-0.27

Uall-0.69

SHGCall-0.27

Uall-1.90

SHGCall-NR

2.1-5.0%

Uall-0.69

SHGCall-0.27

Uall-0.69

SHGCall-0.27

Uall-1.90

SHGCall-NR

Skylight without Curb, All,% of Roof

0-2.0%

Uall-0.45

SHGCall-0.19

Uall-0.45

SHGCall-0.19

Uall-1.36

SHGCall-NR

2.1-5.0%

Uall-0.45

SHGCall-0.19

Uall-0.45

SHGCall-0.19

Uall-1.36

SHGCall-NR

a Mass walls with a heat capacity greater than 12 Btu/ft2·ºF which are unfinished or finished only on the interior do not need to be insulated.

b Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.

c Metal framing includes metal framing with or without thermal break. The all other subcategory includes operable windows, fixed windows, and nonentrance doors.

d Filled cavity with thermal block is as shown in Table A2.3 of Standard 90.1.

Table A-4 (supersedes Table 5.5-4 in ASHRAE/IESNA Standard 90.1)

Building Envelope Requirements For Climate Zone 4 (A,B,C) (I-P)

Nonresidential

Residential

Semiheated

Assembly

Insulation

Assembly

Insulation

Assembly

Insulation

Opaque Elements

Max.

Min. R-Value

Max.

Min. R-Value

Max.

Min.R-Value

Roofs

Insulation Entirely above Deck

U-0.039

R-25.0 ci

U-0.039

R-25.0 ci

U-0.119

R-7.6 ci

Metal Building

U-0.041

R-19.0 + R-10.0
filled cavity w/tbd

U-0.041

R-19.0 + R-10.0
filled cavity w/tbd

U-0.065

R-19.0

Attic and Other

U-0.021

R-49.0

U-0.021

R-49.0

U-0.034

R-30.0

Walls, Above-grade

Mass

U-0.090

R-11.4 ci

U-0.080

R-13.3 ci

U-0.151a

R-5.7 cia

Metal Building

U-0.053

R-13.0 + R-10.0 ci

U-0.053

R-13.0 + R-10.0 ci

U-0.084

R-19.0

Steel Framed

U-0.055

R-13.0 + R-10.0 ci

U-0.055

R-13.0 + R-10.0 ci

U-0.084

R-13.0 +
R-3.8 ci

Wood Framed and Other

U-0.064

R-13.0 + R-3.8 ci

U-0.051

R-13.0 + R-7.5 ci

U-0.064

R-13.0 +
R-3.8 ci

Wall, Below Grade

Below Grade Wall

C-0.119

R-7.5 ci

C-0.092

R-10.0 ci

C-0.119

R-7.5 ci

Floors

Mass

U-0.074

R-10.4 ci

U-0.064

R-12.5 ci

U-0.107

R-6.3 ci

Steel Joist

U-0.032

R-38.0

U-0.032

R-38.0

U-0.052

R-19.0

Wood Framed and Other

U-0.026

R-30.0 + R-7.5 ci

U-0.026

R-30.0 + R-7.5 ci

U-0.051

R-19.0

Slab-On-Grade Floors

Unheated

F-0.540

R-10 for 24 in.

F-0.520

R-15 for 24 in.

F-0.540

R-10 for 24 in.

Heated

F-0.550

R-10.0 for 24 in. +
R-5 ci below

F-0.550

R-10.0 for 24 in. +
R-5 ci below

F-0.950

R-7.5 for 24 in.

Opaque Doors

Swinging

U-0.600

U-0.600

U-0.600

Non-Swinging

U-0.400

U-0.400

U-0.500

Assembly

Assembly

Assembly

Assembly

Assembly

Assembly

Fenestration

Max. U

Max. SHGC

Max. U

Max. SHGC

Max. U

Max. SHGC

Vertical Fenestration,0-40% of Wall

Nonmetal framing: allb

Metal fr: curtainwall/storefrontc

Metal framing: entrance doorc

Metal framing: all otherc

U-0.30

U-0.40

U-0.75

U-0.45

SHGC-0.35 all

U-0.30

U-0.40

U-0.75

U-0.45

SHGC-0.40 all

U-0.55

U-0.60

U-0.80

U-0.65

SHGC-NR all

Skylight with Curb, Glass,% of Roof

0-2.0%

Uall-0.69

SHGCall-0.32

Uall-0.69

SHGCall-0.19

Uall-1.98

SHGCall-NR

2.1-5.0%

Uall-0.69

SHGCall-0.32

Uall-0.69

SHGCall-0.19

Uall-1.98

SHGCall-NR

Skylight with Curb, Plastic,% of Roof

0-2.0%

Uall-0.69

SHGCall-0.34

Uall-0.69

SHGCall-0.27

Uall-1.90

SHGCall-NR

2.1-5.0%

Uall-0.69

SHGCall-0.34

Uall-0.69

SHGCall-0.27

Uall-1.90

SHGCall-NR

Skylight without Curb, All,% of Roof

0-2.0%

Uall-0.45

SHGCall-0.32

Uall-0.45

SHGCall-0.19

Uall-1.36

SHGCall-NR

2.1-5.0%

Uall-0.45

SHGCall-0.32

Uall-0.45

SHGCall-0.19

Uall-1.36

SHGCall-NR

a Mass walls with a heat capacity greater than 12 Btu/ft2·ºF which are unfinished or finished only on the interior do not need to be insulated.

b Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.

c Metal framing includes metal framing with or without thermal break. The all other subcategory includes operable windows, fixed windows, and nonentrance doors.

d Filled cavity with thermal block is as shown in Table A2.3 of Standard 90.1.

Table A-5 (supersedes Table 5.5-5 in ASHRAE/IESNA Standard 90.1)

Building Envelope Requirements For Climate Zone 5 (A,B,C) (I-P)

Nonresidential

Residential

Semiheated

Assembly

Insulation

Assembly

Insulation

Assembly

Insulation

Opaque Elements

Max.

Min. R-Value

Max.

Min. R-Value

Max.

Min.R-Value

Roofs

Insulation Entirely above Deck

U-0.039

R-25.0 ci

U-0.039

R-25.0 ci

U-0.093

R-10.0 ci

Metal Building

U-0.041

R-19.0 + R-10.0
filled cavity w/tbd

U-0.041

R-19.0 + R-10.0
filled cavity w/tbd

U-0.065

R-19.0

Attic and Other

U-0.021

R-49.0

U-0.021

R-49.0

U-0.034

R-30.0

Walls, Above-grade

Mass

U-0.080

R-13.3 ci

U-0.071

R-15.2 ci

U-0.123

R-7.6 ci

Metal Building

U-0.053

R-13.0 + R-10.0 ci

U-0.053

R-13.0 + R-10.0 ci

U-0.084

R-19.0

Steel Framed

U-0.055

R-13.0 + R-10.0 ci

U-0.055

R-13.0 + R-10.0 ci

U-0.084

R-13.0 +
R-3.8 ci

Wood Framed and Other

U-0.051

R-13.0 + R-7.5 ci

U-0.045

R-13.0 + R-10.0 ci

U-0.064

R-13.0 +
R-3.8 ci

Wall, Below Grade

Below Grade Wall

C-0.092

R-10.0 ci

C-0.092

R-10.0 ci

C-0.119

R-7.5 ci

Floors

Mass

U-0.064

R-12.5 ci

U-0.057

R-14.6 ci

U-0.107

R-6.3 ci

Steel Joist

U-0.032

R-38.0

U-0.032

R-38.0

U-0.038

R-30.0

Wood Framed and Other

U-0.026

R-30.0 + R-7.5 ci

U-0.026

R-30.0 + R-7.5 ci

U-0.033

R-30.0

Slab-On-Grade Floors

Unheated

F-0.540

R-10 for 24 in.

F-0.520

R-15 for 24 in.

F-0.540

R-10 for 24 in.

Heated

F-0.440

R-15.0 for 36 in. +
R-5 ci below

F-0.440

R-15.0 for 36 in. +
R-5 ci below

F-0.900

R-10 for 24 in.

Opaque Doors

Swinging

U-0.400

U-0.400

U-0.600

Non-Swinging

U-0.400

U-0.400

U-0.500

Assembly

Assembly

Assembly

Assembly

Assembly

Assembly

Fenestration

Max. U

Max. SHGC

Max. U

Max. SHGC

Max. U

Max. SHGC

Vertical Fenestration,0-40% of Wall

Nonmetal framing: allb

Metal fr: curtainwall/storefrontc

Metal framing: entrance doorc

Metal framing: all otherc

U-0.25

U-0.35

U-0.70

U-0.45

SHGC-0.35 all

U-0.25

U-0.35

U-0.70

U-0.45

SHGC-0.40 all

U-0.55

U-0.60

U-0.80

U-0.65

SHGC-NR all

Skylight with Curb, Glass,% of Roof

0-2.0%

Uall-0.67

SHGCall-0.36

Uall-0.67

SHGCall-0.36

Uall-1.98

SHGCall-NR

2.1-5.0%

Uall-0.67

SHGCall-0.36

Uall-0.67

SHGCall-0.36

Uall-1.98

SHGCall-NR

Skylight with Curb, Plastic,% of Roof

0-2.0%

Uall-0.69

SHGCall-0.34

Uall-0.69

SHGCall-0.34

Uall-1.90

SHGCall-NR

2.1-5.0%

Uall-0.69

SHGCall-0.34

Uall-0.69

SHGCall-0.34

Uall-1.90

SHGCall-NR

Skylight without Curb, All,% of Roof

0-2.0%

Uall-0.45

SHGCall-0.36

Uall-0.45

SHGCall-0.36

Uall-1.36

SHGCall-NR

2.1-5.0%

Uall-0.45

SHGCall-0.36

Uall-0.45

SHGCall-0.36

Uall-1.36

SHGCall-NR

a Mass walls with a heat capacity greater than 12 Btu/ft2·ºF which are unfinished or finished only on the interior do not need to be insulated.

b Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.

c Metal framing includes metal framing with or without thermal break. The all other subcategory includes operable windows, fixed windows, and nonentrance doors.

d Filled cavity with thermal block is as shown in Table A2.3 of Standard 90.1.

Table A-6 (supersedes Table 5.5-6 in ASHRAE/IESNA Standard 90.1)

Building Envelope Requirements For Climate Zone 6 (A,B) (I-P)

Nonresidential

Residential

Semiheated

Assembly

Insulation

Assembly

Insulation

Assembly

Insulation

Opaque Elements

Max.

Min. R-Value

Max.

Min. R-Value

Max.

Min.R-Value

Roofs

Insulation Entirely above Deck

U-0.032

R-30.0 ci

U-0.032

R-30.0 ci

U-0.063

R-15.0 ci

Metal Building

U-0.032

R-30.0 + R-6.0 ci,
filled cavity w/tbd

U-0.032

R-30.0 + R-6.0 ci,
filled cavity w/tbd

U-0.065

R-19.0

Attic and Other

U-0.021

R-49.0

U-0.021

R-49.0

U-0.027

R-38.0

Walls, Above-grade

Mass

U-0.071

R-15.2 ci

U-0.060

R-20.0 ci

U-0.104

R-9.5 ci

Metal Building

U-0.053

R-13.0 + R-10.0 ci

U-0.053

R-13.0 + R-10.0 ci

U-0.084

R-19.0

Steel Framed

U-0.055

R-13.0 + R-10.0 ci

U-0.055

R-13.0 + R-10.0 ci

U-0.084

R-13.0 +
R-3.8 ci

Wood Framed and Other

U-0.045

R-13.0 + R-10.0 ci

U-0.045

R-13.0 + R-10.0 ci

U-0.064

R-13.0 +
R-3.8 ci

Wall, Below Grade

Below Grade Wall

C-0.092

R-10.0 ci

C-0.092

R-10.0 ci

C-0.119

R-7.5 ci

Floors

Mass

U-0.057

R-14.6 ci

U-0.051

R-16.7 ci

U-0.107

R-6.3 ci

Steel Joist

U-0.032

R-38.0

U-0.023

R-38.0 + R-12.5 ci

U-0.038

R-30.0

Wood Framed and Other

U-0.026

R-30.0 + R-7.5 ci

U-0.026

R-30.0 + R-7.5 ci

U-0.033

R-30.0

Slab-On-Grade Floors

Unheated

F-0.520

R-15 for 24 in.

F-0.510

R-20 for 24 in.

F-0.540

R-10 for 24 in.

Heated

F-0.440

R-15.0 for 36 in. +
R-5 ci below

F-0.440

R-15.0 for 36 in. +
R-5 ci below

F-0.900

R-10 for 24 in.

Opaque Doors

Swinging

U-0.400

U-0.400

U-0.600

Non-Swinging

U-0.400

U-0.400

U-0.500

Assembly

Assembly

Assembly

Assembly

Assembly

Assembly

Fenestration

Max. U

Max. SHGC

Max. U

Max. SHGC

Max. U

Max. SHGC

Vertical Fenestration,0-40% of Wall

Nonmetal framing: allb

Metal fr: curtainwall/storefrontc

Metal framing: entrance doorc

Metal framing: all otherc

U-0.25

U-0.35

U-0.70

U-0.45

SHGC-0.40 all

U-0.25

U-0.35

U-0.70

U-0.45

SHGC-0.40 all

U-0.45

U-0.50

U-0.80

U-0.55

SHGC-NR all

Skylight with Curb, Glass,% of Roof

0-2.0%

Uall-0.67

SHGCall-0.46

Uall-0.67

SHGCall-0.46

Uall-1.98

SHGCall-NR

2.1-5.0%

Uall-0.67

SHGCall-0.46

Uall-0.67

SHGCall-0.46

Uall-1.98

SHGCall-NR

Skylight with Curb, Plastic,% of Roof

0-2.0%

Uall-0.69

SHGCall-0.49

Uall-0.69

SHGCall-0.49

Uall-1.90

SHGCall-NR

2.1-5.0%

Uall-0.69

SHGCall-0.49

Uall-0.69

SHGCall-0.49

Uall-1.90

SHGCall-NR

Skylight without Curb, All,% of Roof

0-2.0%

Uall-0.45

SHGCall-0.46

Uall-0.45

SHGCall-0.39

Uall-1.36

SHGCall-NR

2.1-5.0%

Uall-0.45

SHGCall-0.46

Uall-0.45

SHGCall-0.39

Uall-1.36

SHGCall-NR

a Mass walls with a heat capacity greater than 12 Btu/ft2·ºF which are unfinished or finished only on the interior do not need to be insulated.

b Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.

c Metal framing includes metal framing with or without thermal break. The all other subcategory includes operable windows, fixed windows, and nonentrance doors.

d Filled cavity with thermal block is as shown in Table A2.3 of Standard 90.1.

Table A-7 (supersedes Table 5.5-7 in ASHRAE/IESNA Standard 90.1)

Building Envelope Requirements For Climate Zone 7 (I-P)

Nonresidential

Residential

Semiheated

Assembly

Assembly

Assembly

Assembly

Assembly

Assembly

Opaque Elements

Max. U

Max. SHGC

Max. U

Max. SHGC

Max. U

Max. SHGC

Roofs

Insulation Entirely above Deck

U-0.028

R-35.0 ci

U-0.028

R-35.0 ci

U-0.063

R-15.0 ci

Metal Building

U-0.028

R-30.0 + R-10.0 ci,
filled cavity w/tbd

U-0.028

R-30.0 + R-10.0 ci,
filled cavity w/tbd

U-0.065

R-19.0

Attic and Other

U-0.017

R-60.0

U-0.017

R-60.0

U-0.027

R-38.0

Walls, Above-grade

Mass

U-0.060

R-20.0 ci

U-0.060

R-20.0 ci

U-0.090

R-11.4 ci

Metal Building

U-0.053

R-13.0 + R-10.0 ci

U-0.036

R-13.0 + R-18.8 ci

U-0.084

R-19.0

Steel Framed

U-0.055

R-13.0 + R-10.0 ci

U-0.037

R-13.0 + R-18.8 ci

U-0.084

R-13.0 +
R-3.8 ci

Wood Framed and Other

U-0.045

R-13.0 + R-10.0 ci

U-0.045

R-13.0 + R-10.0 ci

U-0.064

R-13.0 +
R-3.8 ci

Wall, Below Grade

Below Grade Wall

C-0.092

R-10.0 ci

C-0.075

R-12.5 ci

C-0.119

R-7.5 ci

Floors

Mass

U-0.043

R-20.0 ci

U-0.043

R-20.0 ci

U-0.087

R-8.3 ci

Steel Joist

U-0.032

R-38.0

U-0.023

R-38.0 + R-12.5 ci

U-0.038

R-30.0

Wood Framed and Other

U-0.026

R-30.0 + R-7.5 ci

U-0.026

R-30.0 + R-7.5 ci

U-0.033

R-30.0

Slab-On-Grade Floors

Unheated

F-0.300

R-15 for 24 in. +

R-5 ci below

F-0.300

R-15 for 24 in. +
R-5 ci below

F-0.540

R-10 for 24 in.

Heated

F-0.373

R-20.0 for 36 in. +
R-5 ci below

F-0.373

R-20.0 for 36 in. +
R-5 ci below

F-0.688

R-20 for 48 in.

Opaque Doors

Swinging

U-0.400

U-0.400

U-0.600

Non-Swinging

U-0.400

U-0.400

U-0.500

Assembly

Assembly Max.

Assembly

Assembly Max.

Assembly

Assembly Max.

Fenestration

Max. U

SHGC

Max. U

SHGC

Max. U

SHGC

Vertical Fenestration,0-40% of Wall

Nonmetal framing: allb

Metal fr: curtainwall/storefrontc

Metal framing: entrance doorc

Metal framing: all otherc

U-0.25

U-0.30

U-0.70

U-0.35

SHGC-0.45 all

U-0.25

U-0.30

U-0.70

U-0.35

SHGC-NR all

U-0.45

U-0.50

U-0.80

U-0.55

SHGC-NR all

Skylight with Curb, Glass,% of Roof

0-2.0%

Uall-0.67

SHGCall-0.46

Uall-0.67

SHGCall-0.46

Uall-1.98

SHGCall-NR

2.1-5.0%

Uall-0.67

SHGCall-0.46

Uall-0.67

SHGCall-0.46

Uall-1.98

SHGCall-NR

Skylight with Curb, Plastic,% of Roof

0-2.0%

Uall-0.69

SHGCall-0.50

Uall-0.69

SHGCall-0.50

Uall-1.90

SHGCall-NR

2.1-5.0%

Uall-0.69

SHGCall-0.50

Uall-0.69

SHGCall-0.50

Uall-1.90

SHGCall-NR

Skylight without Curb, All,% of Roof

0-2.0%

Uall-0.45

SHGCall-0.46

Uall-0.45

SHGCall-0.46

Uall-1.36

SHGCall-NR

2.1-5.0%

Uall-0.45

SHGCall-0.46

Uall-0.45

SHGCall-0.46

Uall-1.36

SHGCall-NR

a Mass walls with a heat capacity greater than 12 Btu/ft2·ºF which are unfinished or finished only on the interior do not need to be insulated.

b Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.

c Metal framing includes metal framing with or without thermal break. The all other subcategory includes operable windows, fixed windows, and nonentrance doors.

d Filled cavity with thermal block is as shown in Table A2.3 of Standard 90.1.

Table A-8 (supersedes Table 5.5-8 in ASHRAE/IESNA Standard 90.1)

Building Envelope Requirements For Climate Zone 8 (I-P)

Nonresidential

Residential

Semiheated

Assembly

Insulation

Assembly

Insulation

Assembly

Insulation

Opaque Elements

Max.

Min. R-Value

Max.

Min. R-Value

Max.

Min.R-Value

Roofs

Insulation Entirely above Deck

U-0.028

R-35.0 ci

U-0.028

R-35.0 ci

U-0.048

R-20.0 ci

Metal Building

U-0.028

R-30.0 + R-10.0 ci,
filled cavity w/tbd

U-0.028

R-30.0 + R-10.0 ci,
filled cavity w/tbd

U-0.049

R-13.0 + R-19.0

Attic and Other

U-0.017

R-60.0

U-0.017

R-60.0

U-0.027

R-38.0

Walls, Above-grade

Mass

U-0.060

R-20.0 ci

U-0.043

R-31.3 ci

U-0.080

R-13.3 ci

Metal Building

U-0.053

R-13.0 + R-10.0 ci

U-0.032

R-13.0 + R-22.4 ci

U-0.061

R-13.0 +
R-7.5 ci

Steel Framed

U-0.055

R-13.0 + R-10.0 ci

U-0.033

R-13.0 + R-21.9 ci

U-0.064

R-13.0 +
R-7.5 ci

Wood Framed and Other

U-0.045

R-13.0 + R-10.0 ci

U-0.032

R-13.0 + R-18.8 ci

U-0.064

R-13.0 +
R-3.8 ci

Wall, Below Grade

Below Grade Wall

C-0.092

R-10.0 ci

C-0.063

R-15.0 ci

C-0.119

R-7.5 ci

Floors

Mass

U-0.043

R-20.0 ci

U-0.043

R-20.0 ci

U-0.064

R-12.5 ci

Steel Joist

U-0.023

R-38.0 + R-12.5 ci

U-0.023

R-38.0 + R-12.5 ci

U-0.038

R-30.0

Wood Framed and Other

U-0.026

R-30.0 + R-7.5 ci

U-0.026

R-30.0 + R-7.5 ci

U-0.026

R-30.0 +
R-7.5 ci

Slab-On-Grade Floors

Unheated

F-0.300

R-15 for 24 in. + R-5ci below

F-0.300

R-15 for 24 in. +
R-5 ci below

F-0.540

R-10 for 24 in.

Heated

F-0.373

R-20.0 for 36 in. +
R-5 ci below

F-0.373

R-20.0 for 36 in. +
R-5 ci below

F-0.688

R-20 for 48 in.

Opaque Doors

Swinging

U-0.400

U-0.400

U-0.400

Non-Swinging

U-0.400

U-0.400

U-0.400

Assembly

Assembly

Assembly

Assembly

Assembly

Assembly

Fenestration

Max. U

Max. SHGC

Max. U

Max. SHGC

Max. U

Max. SHGC

Vertical Fenestration,0-40% of Wall

Nonmetal framing: allb

Metal fr: curtainwall/storefrontc

Metal framing: entrance doorc

Metal framing: all otherc

U-0.25

U-0.30

U-0.70

U-0.35

SHGC-0.45 all

U-0.25

U-0.30

U-0.70

U-0.35

SHGC-NR all

U-0.45

U-0.50

U-0.80

U-0.55

SHGC-NR all

Skylight with Curb, Glass,% of Roof

0-2.0%

Uall-0.58

SHGCall-NR

Uall-0.58

SHGCall-NR

Uall-1.30

SHGCall-NR

2.1-5.0%

Uall-0.58

SHGCall-NR

Uall-0.58

SHGCall-NR

Uall-1.30

SHGCall-NR

Skylight with Curb, Plastic,% of Roof

0-2.0%

Uall-0.58

SHGCall-NR

Uall-0.58

SHGCall-NR

Uall-1.10

SHGCall-NR

2.1-5.0%

Uall-0.58

SHGCall-NR

Uall-0.58

SHGCall-NR

Uall-1.10

SHGCall-NR

Skylight without Curb, All,% of Roof

0-2.0%

Uall-0.45

SHGCall-NR

Uall-0.45

SHGCall-NR

Uall-0.81

SHGCall-NR

2.1-5.0%

Uall-0.45

SHGCall-NR

Uall-0.45

SHGCall-NR

Uall-0.81

SHGCall-NR

a Mass walls with a heat capacity greater than 12 Btu/ft2·ºF which are unfinished or finished only on the interior do not need to be insulated.

b Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.

c Metal framing includes metal framing with or without thermal break. The all other subcategory includes operable windows, fixed windows, and nonentrance doors.

d Filled cavity with thermal block is as shown in Table A2.3 of Standard 90.1.

TABLE A-9 (supersedes Table A2.4.2 in ASHRAE/IESNA Standard 90.1)

Single-Rafter Roof Requirements (I-P)

Climate Zone

Minimum Insulation R-Value or Maximum Assembly U-Factor

Nonresidential

Residential

Semiheated

1

R-38

U-0.029

R-38 + R10 ci

U-0.020

R-19

U-0.055

2

R-38 + R10 ci

U-0.020

R-38 + R10 ci

U-0.020

R-19

U-0.055

3, 4, 5

R-38 + R10 ci

U-0.020

R-38 + R10 ci

U-0.020

R-30

U-0.036

6

R-38 + R10 ci

U-0.020

R-38 + R10 ci

U-0.020

R-38

U-0.029

7, 8

R-38 + R15 ci

U-0.018

R-38 + R15 ci

U-0.018

R-38

U-0.029

(This is a normative appendix and is part of this standard.)

NORMATIVE APPENDIX B

PRESCRIPTIVE CONTINUOUS AIR BARRIER

B1 Characteristics. The continuous air barrier shall have the following characteristics:

(a) It shall be continuous throughout the envelope (at the lowest floor, exterior walls, and ceiling or roof), with all joints and seams sealed and with sealed connections between all transitions in planes and changes in materials and at all penetrations.

(b) The air barrier component of each assembly shall be joined and sealed in a flexible manner to the air barrier component of adjacent assemblies, allowing for the relative movement of these assemblies and components.

(c) It shall be capable of withstanding positive and negative combined design wind, fan and stack pressures on the air barrier without damage or displacement, and shall transfer the load to the structure. It shall not displace adjacent materials under full load.

(d) It shall be installed in accordance with the manufacturer’s instructions and in such a manner as to achieve the performance requirements.

(e) Where lighting fixtures with ventilation holes or other similar objects are to be installed in such a way as to penetrate the continuous air barrier, provisions shall be made to maintain the integrity of the continuous air barrier.

Exception: Buildings that comply with (c) below are not required to comply with either (a) or (e) above.

B2 Compliance. Compliance of the continuous air barrier for the opaque building envelope shall be demonstrated by one of the following:

(a) Materials. Using individual materials that have an air permeability not to exceed 0.02 L/s·m2 under a pressure differential of 75 Pa (0.004 cfm/ft2 under a pressure differential of 0.3 in. water (1.57 lb/ft2)) when tested in accordance with ASTM E2178. These materials comply with this requirement when all joints are sealed and the above section on characteristics are met:

1. Plywood - minimum 10 mm (3/8 in)

2. Oriented strand board - minimum 10 mm (3/8 in)

3. Extruded polystyrene insulation board - minimum 19 mm (3/4 in)

4. Foil-back urethane insulation board - minimum 19 mm (3/4 in)

5. Exterior or interior gypsum board - minimum 12 mm (1/2 in)

6. Cement board - minimum 12 mm (1/2 in)

7. Built up roofing membrane

8. Modified bituminous roof membrane

9. Fully adhered single-ply roof membrane

10. A Portland cement/sand parge, or gypsum plaster minimum 16 mm (5/8 in) thick

11. Cast-in-place and precast concrete.

12. Fully grouted concrete block masonry.

13. Sheet Steel

(b) Assemblies. Using assemblies of materials and components that have an average air leakage not to exceed 0.2 L/s·m2 @ 75 Pa (0.04 cfm/ft2 under a pressure differential of 0.3” w.g. (1.57psf)) when tested in accordance with ASTM E2357 or ASTM E1677. These assemblies comply with this requirement when all joints are sealed and the above section on characteristics are met:

1. Concrete masonry walls coated with:

i. One application of block filler and two applications of a paint or sealer coating, or

ii. A Portland cement/sand parge, stucco or plaster minimum 12 mm (1/2 in) thick.

(c) Building. Testing the completed building and demonstrating that the air leakage rate of the building envelope does not exceed 2.0 L/s·m2 @ 75 Pa (0.40 cfm/ft2 at a pressure differential of 0.3” w.g. (1.57 psf)) in accordance with ASTM E779 or an equivalent approved method.

(This is a normative appendix and is part of this standard.)

NORMATIVE APPENDIX C

PRESCRIPTIVE EQUIPMENT EFFICIENCY REQUIREMENTS

(Informative note: The first 23 tables are in SI units, the next 23 tables are in I-P units.)

Table C-1 (supersedes Table 6.8.1A in ASHRAE/IESNA Standard 90.1) –

Electrical Operated Unitary Air Conditioners and Condensing Units (SI)

Equipment Type	Size Category	Heating Section Type	Sub-Category or Rating Conditions	Minimum Efficiency	Test Procedure
Air Conditioners, Air Cooled	<19 kW	All	Split Systems		

4.10 SCOP
3.52 COP

ARI 210/240

Single Packaged

4.10 SCOP
3.52 COP

ARI 210/240

Through-the-wall Air Cooled

<9 kW

All

Split Systems

3.52 SCOP

ARI 210/240

Single Packaged

3.52 SCOP

ARI 210/240

Small-Duct High Velocity,
Air-Cooled

<19kW

All

Split Systems

2.93 SCOP

ARI 210/240

Air Conditioners,
Air Cooled

>19 kW and
< 40 kW

Electric Resistance
(or None)

Split Systems and
Single Package

3.37 COP
3.52 ICOP

ARI 340/360

All other

Split Systems and
Single Package

3.31 COP
3.46 ICOP

ARI 340/360

>40 kW and
< 70 kW

Electric Resistance
(or None)

Split Systems and
Single Package

3.37 COP
3.52 ICOP

ARI 340/360

All other

Split Systems and
Single Package

3.31 COP
3.46 ICOP

ARI 340/360

>70 kW and
< 223 kW

Electric Resistance
(or None)

Split Systems and
Single Package

2.93 COP
3.08 ICOP

ARI 340/360

All other

Split Systems and
Single Package

2.87 COP
3.02 ICOP

ARI 340/360

>223 kW

Electric Resistance
(or None)

Split Systems and
Single Package

2.84 COP
2.99 ICOP

ARI 340/360

All other

Split Systems and
Single Package

2.78 COP
2.93 ICOP

ARI 340/360

Table C-1 (supersedes Table 6.8.1A in ASHRAE/IESNA Standard 90.1) –

Electrical Operated Unitary Air Conditioners and Condensing Units (SI) (continued)

Equipment Type	Size Category	Heating Section Type	Sub-Category or Rating Conditions	Minimum Efficiency	Test Procedure
Air Conditioners, Water and Evaporatively Cooled	<19kW	All	Split Systems and Single Package	4.10 COP 4.19 ICOP	ARI 210/240
	>19 kW and < 40 kW	Electric Resistance (or None)	Split Systems and Single Package	4.10 COP	

4.19 ICOP

ARI 340/360

All other

Split Systems and
Single Package

4.04 COP
4.13 ICOP

ARI 340/360

>40 kW and
< 70 kW

Electric Resistance
(or None)

Split Systems and
Single Package

4.10 COP
4.19 ICOP

ARI 340/360

All other

Split Systems and
Single Package

3.81 COP
4.13 ICOP

ARI 340/360

>70 kW Btu/h

Electric Resistance
(or None)

Split Systems and
Single Package

4.10 COP
4.10 ICOP

ARI 340/360

All other

Split Systems and
Single Package

3.81 COP
3.81 ICOP

ARI 340/360

Condensing Units,
Air Cooled

> 40 kW

not applicable
match with indoor
coil

ARI 365

Condensing, Water or
Evaporatively Cooled

> 40 kW

not applicable
match with indoor
coil

ARI 365

Table C-2 (supersedes Table 6.8.1B in ASHRAE/IESNA Standard 90.1) –

Electrically Operated Unitary and Applied Heat Pumps
Minimum Efficiency Requirements (SI)

Equipment Type

Size Category

Heating Section Type

Sub-Category or
Rating Conditions

Minimum
Efficiency

Test
Procedure

Air Conditioners,
Air Cooled
(Cooling Mode)

<19 kW

All

Split Systems

4.10 SCOPC
3.52 COPC

ARI 210/240

Single Packaged

4.10 SCOPC
3.40 COPC

Through-the-wall Air
Cooled
(Cooling Mode)

<9 kW

All

Split Systems

3.52 SCOPC

Single Packaged

3.52 SCOPC

Small-Duct High Velocity,
Air-Cooled
(Cooling Mode)

<19 kW

All

Split Systems

2.93 SCOPC

Air Conditioners,
Air Cooled
(Cooling Mode)

>19 kW and
< 40 kW

Electric Resistance
(or None)

Split Systems and
Single Package

3.31 COPC
3.46 ICOPC

ARI 340/360

All other

Split Systems and

Single Package

3.25 COPC
3.40 ICOPC

>40 kW and
< 70 kW

Electric Resistance
(or None)

Split Systems and
Single Package

3.32 COPC
3.46 ICOPC

All other

Split Systems and
Single Package

3.25 COPC
3.40 ICOPC

>70 kW

Electric Resistance
(or None)

Split Systems and
Single Package

2.87 COPC
2.87 ICOPC

All other

Split Systems and
Single Package

2.81 COPC
2.81 ICOPC

Water-Source
(Cooling Mode)

<5 kW

All

30 C Entering Water

4.10 COPC

ISO-13256-1

>5 kW and
< 19 kW

All

30 C Entering Water

4.10 COPC

>19 kW and
< 40 kW

All

30 C Entering Water

4.10 COPC

Groundwater-Source
(Cooling Mode)

< 40 kW

All

15 C Entering Water

4.75 COPC

All

25 C Entering Water

13.4 COPC

Table C-2 (supersedes Table 6.8.1B in ASHRAE/IESNA Standard 90.1) –

Electrically Operated Unitary and Applied Heat Pumps
Minimum Efficiency Requirements (SI) (continued)

Equipment Type

Size Category

Heating Section Type

Sub-Category or
Rating Conditions

Minimum
Efficiency

Test
Procedure

Air Conditioners,
Air Cooled
(Heating Mode)

<19 kW

All

Split Systems

2.49 SCOPH

ARI210/240

Single Packaged

2.34 SCOPH

Through-the-wall Air
Cooled
(Heating Mode)

<9 kW

All

Split Systems

2.17 SCOPH

Single Packaged

2.17 SCOPH

Small-Duct High Velocity,
Air-Cooled
(Heating Mode)

<19 kW

All

Split Systems

1.99 SCOPH

Air Cooled
(Heating Mode)

>19 kW and <40 kW
(Cooling Capacity)

8C DB/6C WB
Outdoor Air

3.3 COPH

ARI 340/360

-8 C DB/-9 C WB
Outdoor Air

2.2 COPH

>40 kW

(Cooling Capacity)

8C DB/6C WB
Outdoor Air

3.2 COPH

-8 C DB/-9 C WB
Outdoor Air

2.0 COPH

Water-Source
(Heating Mode)

< 40 kW
(Cooling Capacity)

19 C Entering Water

4.2 COPH

ISO-13256-1

Groundwater-Source
(Heating Mode)

< kW
(Cooling Capacity)

10 C Entering Water

3.6 COPH

0 C Entering Fluid

3.1 COPH

Table C-3 (supersedes Table 6.8.1C in ASHRAE/IESNA Standard 90.1)

Water Chilling Packages – Minimum Efficiency Requirements (SI)

Equipment Type

Size Category

Units

Minimum Efficiency

Test
Procedure

Path A

Path B

Full Load

IPLV

Full Load

IPLV

Air Cooled Chillers
with Condenser,
Electrically Operated

<528 kW

COP

2.931

3.664

NA

NA

ARI 550/590

>528 kW

COP

2.931

3.737

NA

NA

Air Cooled without
Condenser, Electrical
Operated

All Capacities

COP

condenserless units shall be rated with
matched condensers

ARI 550/590

Water cooled,
Electrically Operated,
Positive Displacement
(Reciprocating)

All Capacities

COP

reciprocating units required to comply
with water cooled positive displacement
requirements

ARI 550/590

Water Cooled
Electrically Operated,
Positive Displacement

<264 kW

COP

4.509

5.583

4.396

5.862

ARI 550/590

>264 kW and < 528 kW

COP

4.538

5.719

4.452

6.002

> 528 kW and < 1055 kW

COP

5.172

6.064

4.898

6.513

>1055 kW

COP

5.673

6.513

5.504

7.178

Water Cooled
Electrically Operated,
Centrifugal

<528 kW

COP

5.547

5.901

5.504

7.816

ARI 550/590

> 528 kW and < 1055 kW

COP

5.547

5.901

5.504

7.816

> 1055 kW and <2110 kW

COP

6.106

6.406

5.862

8.792

> 2110 kW

COP

6.170

6.525

5.961

8.792

Air Cooled Absorption
Single Effecth

All Capacities

COP

0.600

NR

NA

NA

ARI 560

Water-Cooled
Absorption
Single Effecth

All Capacities

COP

0.700

NR

NA

NA

Absorption Double

Effect
Indirect-Fired

All Capacities

COP

1.000

1.050

NA

NA

Absorption Double
Effect
Direct Fired

All Capacities

COP

1.000

1.000

NA

NA

a. The chiller equipment requirements do not apply for chillers used in low-temperature applications where the design
leaving fluid temperature is <2.4 C

b Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of
the test procedure

c. Where there is a Column A and Column B requirement either column can be used for compliance, but both the full and
IPLV values shall be complied with

d. Path A is intended for applications where significant operating time is expected at full load and design ambient

e. Path B is intended for applications with significant operating time at part load. All path B machines shall be equipped
with demand limiting capable controls

f. NA means that this requirement is not applicable and can not be used for compliance

g. NR means that for this category there are no minimum requirements

h. Only allowed to be used in heat recovery applications

Table C-4 (supersedes Table 6.2.1H in ASHRAE/IESNA Standard 90.1)

Column A Minimum Efficiencies for Centrifugal Chillers <527 kW (SI)

full load COP std =

5.547

IPLV COP std =

5.901

Condenser Flow Rate

10.2

l/min-kW

12.7

l/min-kW

15.3

l/min-kW

20.4

l/min-kW

25.5

l/min-kW

30.6

l/min-kW

Leaving
Chilled
Water
Temp
(C)

Entering
Condenser
Water
Temp (C)

Lifta
(F)

FL
COP

NPLV
COP

FL
COP

NPLV
COP

FL
COP

NPLV
COP

FL
COP

NPLV
COP

FL
COP

NPLV
COP

FL
COP

NPLV
COP

4.4

23.9

19.4

5.674

6.036

5.918

6.296

6.077

6.464

6.287

6.688

6.427

6.837

6.529

6.945

4.4

26.7

22.2

5.121

5.448

5.458

5.806

5.644

6.004

5.852

6.225

5.970

6.351

6.049

6.435

4.4

29.4

25.0

4.256

4.527

4.791

5.097

5.077

5.401

5.371

5.714

5.522

5.874

5.614

5.972

5.0

23.9

18.9

5.764

6.131

6.003

6.385

6.164

6.557

6.385

6.792

6.536

6.953

6.647

7.070

5.0

26.7

21.7

5.251

5.585

5.560

5.915

5.735

6.101

5.936

6.315

6.055

6.441

6.136

6.527

5.0

29.4

24.4

4.463

4.747

4.950

5.266

5.210

5.543

5.480

5.830

5.620

5.978

5.707

6.070

5.6

23.9

18.3

5.850

6.223

6.088

6.476

6.255

6.654

6.491

6.905

6.655

7.079

6.776

7.208

5.6

26.7

21.1

5.369

5.711

5.656

6.017

5.823

6.194

6.020

6.404

6.141

6.533

6.225

6.622

5.6

29.4

23.9

4.652

4.948

5.095

5.420

5.332

5.672

5.581

5.937

5.712

6.077

5.795

6.164

6.1

23.9

17.8

5.935

6.313

6.175

6.569

6.351

6.756

6.605

7.027

6.784

7.217

6.917

7.358

6.1

26.7

20.6

5.478

5.827

5.747

6.113

5.908

6.284

6.106

6.495

6.231

6.628

6.320

6.722

6.1

29.4

23.3

4.823

5.131

5.227

5.560

5.444

5.791

5.676

6.037

5.801

6.170

5.881

6.255

6.7

23.9

17.2

6.019

6.403

6.267

6.666

6.454

6.866

6.730

7.160

6.926

7.368

7.072

7.523

6.7

26.7

20.0

5.579

5.935

5.834

6.205

5.992

6.374

6.194

6.589

6.326

6.729

6.420

6.830

6.7

29.4

22.8

4.979

5.297

5.347

5.688

5.548

5.901

5.765

6.133

5.886

6.261

5.965

6.345

7.2

23.9

16.7

6.104

6.493

6.364

6.770

6.565

6.984

6.867

7.305

7.082

7.534

7.243

7.704

7.2

26.7

19.4

5.674

6.036

5.918

6.296

6.077

6.464

6.287

6.688

6.427

6.837

6.529

6.945

7.2

29.4

22.2

5.121

5.448

5.458

5.806

5.644

6.004

5.852

6.225

5.970

6.351

6.049

6.435

7.8

23.9

16.1

6.192

6.587

6.468

6.880

6.687

7.113

7.018

7.465

7.254

7.717

7.430

7.904

7.8

26.7

18.9

5.764

6.131

6.003

6.385

6.164

6.557

6.385

6.792

6.536

6.953

6.647

7.070

7.8

29.4

21.7

5.251

5.585

5.560

5.915

5.735

6.101

5.936

6.315

6.055

6.441

6.136

6.527

8.3

23.9

15.6

6.285

6.686

6.580

7.000

6.819

7.254

7.183

7.641

7.443

7.917

7.636

8.123

8.3

26.7

18.3

5.850

6.223

6.088

6.476

6.255

6.654

6.491

6.905

6.655

7.079

6.776

7.208

8.3

29.4

21.1

5.369

5.711

5.656

6.017

5.823

6.194

6.020

6.404

6.141

6.533

6.225

6.622

8.9

23.9

15.0

6.383

6.790

6.703

7.130

6.965

7.409

7.364

7.834

7.650

8.138

7.863

8.364

8.9

26.7

17.8

5.935

6.313

6.175

6.569

6.351

6.756

6.605

7.027

6.784

7.217

6.917

7.358

8.9

29.4

20.6

5.478

5.827

5.747

6.113

5.908

6.284

6.106

6.495

6.231

6.628

6.320

6.722

Condenser DTb

7.80

6.24

5.20

3.90

3.12

2.60

a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature

b Condenser DT = Leaving Condenser Water Temperature (C) - Entering Condenser Water Temperature ©

c All NPLV values shown are NPLV except at conditions of 15.3 L/MIN-Kw Condenser Flow Rate with 6.7°C Leaving Chilled Water
Temperature and 29.4 C Entering Condenser Water Temperature which is IPLV

Kadj = 6.17568 - 0.303668(X) + 0.00629466(X)2 - 0.000045780(X)3

where X = Condenser DT + LIFT

kw/tonadj = COP * Kadj

Table C-5 (supersedes Table 6.2.1I in ASHRAE/IESNA Standard 90.1)

Column A Minimum Efficiencies for Centrifugal Chillers >527 kW, <1055 kW (SI)

Column A Centrifugal Chillers > 150 tons and < 300 tons

full load COP std =

5.547

IPLV COP std =

5.901

Condenser Flow Rate

10.2

l/min-kW

12.7

l/min-kW

15.3

l/min-kW

20.4

l/min-kW

25.5

l/min-kW

30.6

l/min-kW

Leaving Chilled
Water
Temperature
(C)

Entering
Condenser
Water Temp
(C)

Lifta
(F)

FL
COP

NPLV
COP

FL
COP

NPLV
COP

FL
COP

NPLV
COP

FL
COP

NPLV
COP

FL
COP

NPLV
COP

FL
COP

NPLV
COP

4.4

23.9

19.4

5.674

6.036

5.918

6.296

6.077

6.464

6.287

6.688

6.427

6.837

6.529

6.945

4.4

26.7

22.2

5.121

5.448

5.458

5.806

5.644

6.004

5.852

6.225

5.970

6.351

6.049

6.435

4.4

29.4

25.0

4.256

4.527

4.791

5.097

5.077

5.401

5.371

5.714

5.522

5.874

5.614

5.972

5.0

23.9

18.9

5.764

6.131

6.003

6.385

6.164

6.557

6.385

6.792

6.536

6.953

6.647

7.070

5.0

26.7

21.7

5.251

5.585

5.560

5.915

5.735

6.101

5.936

6.315

6.055

6.441

6.136

6.527

5.0

29.4

24.4

4.463

4.747

4.950

5.266

5.210

5.543

5.480

5.830

5.620

5.978

5.707

6.070

5.6

23.9

18.3

5.850

6.223

6.088

6.476

6.255

6.654

6.491

6.905

6.655

7.079

6.776

7.208

5.6

26.7

21.1

5.369

5.711

5.656

6.017

5.823

6.194

6.020

6.404

6.141

6.533

6.225

6.622

5.6

29.4

23.9

4.652

4.948

5.095

5.420

5.332

5.672

5.581

5.937

5.712

6.077

5.795

6.164

6.1

23.9

17.8

5.935

6.313

6.175

6.569

6.351

6.756

6.605

7.027

6.784

7.217

6.917

7.358

6.1

26.7

20.6

5.478

5.827

5.747

6.113

5.908

6.284

6.106

6.495

6.231

6.628

6.320

6.722

6.1

29.4

23.3

4.823

5.131

5.227

5.560

5.444

5.791

5.676

6.037

5.801

6.170

5.881

6.255

6.7

23.9

17.2

6.019

6.403

6.267

6.666

6.454

6.866

6.730

7.160

6.926

7.368

7.072

7.523

6.7

26.7

20.0

5.579

5.935

5.834

6.205

5.992

6.374

6.194

6.589

6.326

6.729

6.420

6.830

6.7

29.4

22.8

4.979

5.297

5.347

5.688

5.548

5.901

5.765

6.133

5.886

6.261

5.965

6.345

7.2

23.9

16.7

6.104

6.493

6.364

6.770

6.565

6.984

6.867

7.305

7.082

7.534

7.243

7.704

7.2

26.7

19.4

5.674

6.036

5.918

6.296

6.077

6.464

6.287

6.688

6.427

6.837

6.529

6.945

7.2

29.4

22.2

5.121

5.448

5.458

5.806

5.644

6.004

5.852

6.225

5.970

6.351

6.049

6.435

7.8

23.9

16.1

6.192

6.587

6.468

6.880

6.687

7.113

7.018

7.465

7.254

7.717

7.430

7.904

7.8

26.7

18.9

5.764

6.131

6.003

6.385

6.164

6.557

6.385

6.792

6.536

6.953

6.647

7.070

7.8

29.4

21.7

5.251

5.585

5.560

5.915

5.735

6.101

5.936

6.315

6.055

6.441

6.136

6.527

8.3

23.9

15.6

6.285

6.686

6.580

7.000

6.819

7.254

7.183

7.641

7.443

7.917

7.636

8.123

8.3

26.7

18.3

5.850

6.223

6.088

6.476

6.255

6.654

6.491

6.905

6.655

7.079

6.776

7.208

8.3

29.4

21.1

5.369

5.711

5.656

6.017

5.823

6.194

6.020

6.404

6.141

6.533

6.225

6.622

8.9

23.9

15.0

6.383

6.790

6.703

7.130

6.965

7.409

7.364

7.834

7.650

8.138

7.863

8.364

8.9

26.7

17.8

5.935

6.313

6.175

6.569

6.351

6.756

6.605

7.027

6.784

7.217

6.917

7.358

8.9

29.4

20.6

5.478

5.827

5.747

6.113

5.908

6.284

6.106

6.495

6.231

6.628

6.320

6.722

Condenser DTb

14.04

11.23

9.36

7.02

5.62

4.68

a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature

b Condenser DT = Leaving Condenser Water Temperature (C) - Entering Condenser Water Temperature ©

c All NPLV values shown are NPLV except at conditions of 15.3 L/MIN-Kw Condenser Flow Rate with 6.7°C Leaving Chilled Water
Temperature and 29.4 C Entering Condenser Water Temperature which is IPLV

Kadj = 6.17568 - 0.303668(X) + 0.00629466(X)2 - 0.000045780(X)3

where X = Condenser DT + LIFT

kw/tonadj = COP * Kadj

Table C-6 (supersedes Table 6.2.1J in ASHRAE/IESNA Standard 90.1)

Column A Minimum Efficiencies for Centrifugal Chillers >1055 kW tons, <2108 kW (SI)

full load COP std =

6.106

IPLV COP std =

6.406

Condenser Flow Rate

10.2

l/min-kW

12.7

l/min-kW

15.3

l/min-kW

20.4

l/min-kW

25.5

l/min-kW

30.6

l/min-kW

Leaving
Chilled
Water
Temperature
(C)

Entering
Condenser
Water
Temperature
(C)

Lifta
(F)

FL
COP

NPLV
COP

FL
COP

NPLV
COP

FL
COP

NPLV
COP

FL
COP

NPLV
COP

FL

COP

NPLV
COP

FL
COP

NPLV
COP

4.4

23.9

19.4

6.245

6.552

6.514

6.835

6.689

7.018

6.920

7.260

7.074

7.422

7.186

7.540

4.4

26.7

22.2

5.637

5.914

6.007

6.303

6.212

6.518

6.441

6.758

6.571

6.895

6.658

6.986

4.4

29.4

25.0

4.684

4.915

5.274

5.533

5.588

5.863

5.912

6.203

6.078

6.377

6.179

6.483

5.0

23.9

18.9

6.344

6.656

6.607

6.932

6.785

7.118

7.028

7.374

7.194

7.548

7.316

7.676

5.0

26.7

21.7

5.779

6.063

6.120

6.421

6.313

6.623

6.534

6.855

6.664

6.992

6.753

7.086

5.0

29.4

24.4

4.912

5.154

5.449

5.717

5.735

6.017

6.032

6.329

6.186

6.490

6.281

6.590

5.6

23.9

18.3

6.439

6.756

6.701

7.030

6.885

7.223

7.145

7.496

7.325

7.685

7.458

7.825

5.6

26.7

21.1

5.910

6.200

6.226

6.532

6.409

6.724

6.627

6.953

6.760

7.092

6.852

7.189

5.6

29.4

23.9

5.120

5.372

5.608

5.884

5.869

6.158

6.143

6.445

6.288

6.597

6.378

6.692

6.1

23.9

17.8

6.532

6.853

6.797

7.131

6.991

7.334

7.271

7.628

7.467

7.835

7.613

7.988

6.1

26.7

20.6

6.030

6.326

6.325

6.636

6.502

6.822

6.721

7.051

6.859

7.196

6.956

7.298

6.1

29.4

23.3

5.309

5.570

5.753

6.036

5.992

6.287

6.247

6.554

6.385

6.699

6.473

6.791

6.7

23.9

17.2

6.625

6.951

6.898

7.237

7.104

7.453

7.408

7.772

7.624

7.999

7.784

8.167

6.7

26.7

20.0

6.141

6.443

6.421

6.737

6.595

6.919

6.818

7.153

6.963

7.305

7.067

7.414

6.7

29.4

22.8

5.480

5.750

5.885

6.175

6.106

6.406

6.346

6.658

6.479

6.797

6.565

6.888

7.2

23.9

16.7

6.719

7.049

7.005

7.349

7.227

7.582

7.559

7.930

7.796

8.179

7.972

8.364

7.2

26.7

19.4

6.245

6.552

6.514

6.835

6.689

7.018

6.920

7.260

7.074

7.422

7.186

7.540

7.2

29.4

22.2

5.637

5.914

6.007

6.303

6.212

6.518

6.441

6.758

6.571

6.895

6.658

6.986

7.8

23.9

16.1

6.816

7.151

7.119

7.469

7.360

7.722

7.724

8.104

7.985

8.377

8.178

8.581

7.8

26.7

18.9

6.344

6.656

6.607

6.932

6.785

7.118

7.028

7.374

7.194

7.548

7.316

7.676

7.8

29.4

21.7

5.779

6.063

6.120

6.421

6.313

6.623

6.534

6.855

6.664

6.992

6.753

7.086

8.3

23.9

15.6

6.918

7.258

7.243

7.599

7.506

7.875

7.906

8.295

8.192

8.595

8.405

8.819

8.3

26.7

18.3

6.439

6.756

6.701

7.030

6.885

7.223

7.145

7.496

7.325

7.685

7.458

7.825

8.3

29.4

21.1

5.910

6.200

6.226

6.532

6.409

6.724

6.627

6.953

6.760

7.092

6.852

7.189

8.9

23.9

15.0

7.026

7.371

7.378

7.741

7.666

8.043

8.106

8.505

8.421

8.835

8.654

9.080

8.9

26.7

17.8

6.532

6.853

6.797

7.131

6.991

7.334

7.271

7.628

7.467

7.835

7.613

7.988

8.9

29.4

20.6

6.030

6.326

6.325

6.636

6.502

6.822

6.721

7.051

6.859

7.196

6.956

7.298

Condenser DTb

7.80

6.24

5.20

3.90

3.12

2.60

a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature

b Condenser DT = Leaving Condenser Water Temperature (C) - Entering Condenser Water Temperature ©

c All NPLV values shown are NPLV except at conditions of 15.3 L/MIN-Kw Condenser Flow Rate with 6.7°C Leaving Chilled Water
Temperature and 29.4 C Entering Condenser Water Temperature which is IPLV

Kadj = 6.17568 - 0.303668(X) + 0.00629466(X)2 - 0.000045780(X)3

where X = Condenser DT + LIFT

kw/tonadj = COP * Kadj

Table C-7 (supersedes Table 6.2.1K in ASHRAE/IESNA Standard 90.1)

Column A Minimum Efficiencies for Centrifugal Chillers >2108 kW (SI)

full load COP std =

6.170

IPLV COP std =

6.525

Condenser Flow Rate

10.2

l/min-kW

12.7

l/min-kW

15.3

l/min-kW

20.4

l/min-kW

25.5

l/min-kW

30.6

l/min-kW

Leaving
Chilled
Water
Temperature
(C)

Entering
Condenser
Water
Temperature
(C)

Lifta
(F)

FL
COP

NPLV
COP

FL
COP

NPLV
COP

FL
COP

NPLV
COP

FL
COP

NPLV
COP

FL
COP

NPLV
COP

FL
COP

NPLV
COP

4.4

23.9

19.4

6.311

6.674

6.583

6.961

6.759

7.148

6.993

7.395

7.149

7.560

7.262

7.680

4.4

26.7

22.2

5.696

6.024

6.071

6.420

6.278

6.639

6.509

6.883

6.641

7.022

6.729

7.116

4.4

29.4

25.0

4.734

5.006

5.329

5.636

5.647

5.972

5.974

6.318

6.142

6.495

6.244

6.603

5.0

23.9

18.9

6.411

6.779

6.677

7.061

6.856

7.250

7.102

7.511

7.270

7.688

7.393

7.818

5.0

26.7

21.7

5.840

6.176

6.185

6.540

6.379

6.746

6.603

6.982

6.735

7.122

6.825

7.217

5.0

29.4

24.4

4.964

5.250

5.506

5.823

5.795

6.129

6.095

6.446

6.251

6.610

6.347

6.712

5.6

23.9

18.3

6.507

6.881

6.771

7.161

6.957

7.357

7.220

7.635

7.402

7.828

7.536

7.970

5.6

26.7

21.1

5.972

6.315

6.291

6.653

6.476

6.849

6.696

7.082

6.831

7.224

6.924

7.322

5.6

29.4

23.9

5.174

5.471

5.667

5.993

5.931

6.272

6.208

6.565

6.354

6.719

6.446

6.816

6.1

23.9

17.8

6.601

6.981

6.869

7.264

7.064

7.470

7.347

7.770

7.546

7.980

7.693

8.136

6.1

26.7

20.6

6.093

6.444

6.392

6.759

6.571

6.949

6.792

7.182

6.931

7.329

7.029

7.433

6.1

29.4

23.3

5.365

5.673

5.813

6.148

6.055

6.404

6.313

6.676

6.452

6.823

6.541

6.917

6.7

23.9

17.2

6.695

7.080

6.970

7.371

7.179

7.592

7.486

7.917

7.704

8.147

7.866

8.318

6.7

26.7

20.0

6.206

6.562

6.489

6.862

6.665

7.048

6.890

7.286

7.036

7.441

7.141

7.552

6.7

29.4

22.8

5.538

5.857

5.947

6.289

6.170

6.525

6.413

6.781

6.547

6.923

6.635

7.016

7.2

23.9

16.7

6.790

7.180

7.078

7.485

7.303

7.723

7.638

8.078

7.878

8.331

8.056

8.519

7.2

26.7

19.4

6.311

6.674

6.583

6.961

6.759

7.148

6.993

7.395

7.149

7.560

7.262

7.680

7.2

29.4

22.2

5.696

6.024

6.071

6.420

6.278

6.639

6.509

6.883

6.641

7.022

6.729

7.116

7.8

23.9

16.1

6.888

7.284

7.194

7.608

7.437

7.865

7.805

8.254

8.069

8.533

8.265

8.740

7.8

26.7

18.9

6.411

6.779

6.677

7.061

6.856

7.250

7.102

7.511

7.270

7.688

7.393

7.818

7.8

29.4

21.7

5.840

6.176

6.185

6.540

6.379

6.746

6.603

6.982

6.735

7.122

6.825

7.217

8.3

23.9

15.6

6.991

7.393

7.319

7.740

7.585

8.021

7.989

8.449

8.279

8.755

8.494

8.982

8.3

26.7

18.3

6.507

6.881

6.771

7.161

6.957

7.357

7.220

7.635

7.402

7.828

7.536

7.970

8.3

29.4

21.1

5.972

6.315

6.291

6.653

6.476

6.849

6.696

7.082

6.831

7.224

6.924

7.322

8.9

23.9

15.0

7.100

7.508

7.456

7.884

7.747

8.192

8.191

8.662

8.509

8.999

8.745

9.248

8.9

26.7

17.8

6.601

6.981

6.869

7.264

7.064

7.470

7.347

7.770

7.546

7.980

7.693

8.136

8.9

29.4

20.6

6.093

6.444

6.392

6.759

6.571

6.949

6.792

7.182

6.931

7.329

7.029

7.433

Condenser DTb

7.80

6.24

5.20

3.90

3.12

2.60

a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature

b Condenser DT = Leaving Condenser Water Temperature (C) - Entering Condenser Water Temperature ©

c All NPLV values shown are NPLV except at conditions of 15.3 L/MIN-Kw Condenser Flow Rate with 6.7°C Leaving Chilled Water
Temperature and 29.4 C Entering Condenser Water Temperature which is IPLV

Kadj = 6.17568 - 0.303668(X) + 0.00629466(X)2 - 0.000045780(X)3

where X = Condenser DT + LIFT

kw/tonadj = COP * Kadj

Table C-8 (supersedes Table 6.2.1L in ASHRAE/IESNA Standard 90.1)

Column B Minimum Efficiencies for Centrifugal Chillers <527kW (SI)

full load COP std =

5.504

IPLV COP std =

7.816

Condenser Flow Rate

10.2

l/min-kW

12.7

l/min-kW

15.3

l/min-kW

20.4

l/min-kW

25.5

l/min-kW

30.6

l/min-kW

Leaving
Chilled
Water
Temperature
(C)

Entering
Condenser
Water
Temperature
(C)

Lifta
(F)

FL
COP

NPLV
COP

FL
COP

NPLV
COP

FL
COP

NPLV
COP

FL
COP

NPLV
COP

FL
COP

NPLV
COP

FL
COP

NPLV
COP

4.4

23.9

19.4

5.629

7.994

5.872

8.338

6.029

8.561

6.238

8.857

6.377

9.055

6.478

9.198

4.4

26.7

22.2

5.081

7.215

5.415

7.689

5.600

7.952

5.806

8.244

5.924

8.411

6.002

8.523

4.4

29.4

25.0

4.222

5.996

4.754

6.751

5.037

7.153

5.329

7.568

5.479

7.780

5.570

7.909

5.0

23.9

18.9

5.718

8.120

5.956

8.457

6.116

8.684

6.335

8.996

6.485

9.209

6.595

9.364

5.0

26.7

21.7

5.209

7.397

5.517

7.834

5.690

8.080

5.890

8.363

6.007

8.531

6.088

8.644

5.0

29.4

24.4

4.428

6.288

4.912

6.974

5.170

7.341

5.437

7.721

5.576

7.918

5.662

8.040

5.6

23.9

18.3

5.804

8.242

6.040

8.577

6.206

8.812

6.440

9.145

6.603

9.376

6.723

9.546

5.6

26.7

21.1

5.327

7.564

5.612

7.969

5.777

8.203

5.973

8.482

6.093

8.652

6.176

8.771

5.6

29.4

23.9

4.615

6.554

5.055

7.178

5.290

7.512

5.537

7.863

5.668

8.048

5.750

8.164

6.1

23.9

17.8

5.888

8.361

6.127

8.700

6.301

8.948

6.554

9.306

6.731

9.558

6.863

9.745

6.1

26.7

20.6

5.435

7.718

5.702

8.096

5.861

8.323

6.058

8.603

6.182

8.779

6.270

8.904

6.1

29.4

23.3

4.785

6.795

5.186

7.364

5.401

7.670

5.631

7.996

5.755

8.172

5.835

8.285

6.7

23.9

17.2

5.972

8.480

6.218

8.829

6.404

9.093

6.678

9.482

6.872

9.758

7.017

9.964

6.7

26.7

20.0

5.535

7.860

5.788

8.219

5.945

8.442

6.146

8.727

6.276

8.912

6.370

9.045

6.7

29.4

22.8

4.940

7.015

5.305

7.533

5.504

7.816

5.720

8.123

5.840

8.293

5.918

8.404

7.2

23.9

16.7

6.057

8.600

6.314

8.966

6.514

9.250

6.814

9.675

7.027

9.978

7.186

10.204

7.2

26.7

19.4

5.629

7.994

5.872

8.338

6.029

8.561

6.238

8.857

6.377

9.055

6.478

9.198

7.2

29.4

22.2

5.081

7.215

5.415

7.689

5.600

7.952

5.806

8.244

5.924

8.411

6.002

8.523

7.8

23.9

16.1

6.144

8.725

6.417

9.112

6.634

9.421

6.963

9.887

7.197

10.220

7.372

10.468

7.8

26.7

18.9

5.718

8.120

5.956

8.457

6.116

8.684

6.335

8.996

6.485

9.209

6.595

9.364

7.8

29.4

21.7

5.209

7.397

5.517

7.834

5.690

8.080

5.890

8.363

6.007

8.531

6.088

8.644

8.3

23.9

15.6

6.236

8.855

6.529

9.271

6.766

9.608

7.127

10.120

7.385

10.486

7.577

10.759

8.3

26.7

18.3

5.804

8.242

6.040

8.577

6.206

8.812

6.440

9.145

6.603

9.376

6.723

9.546

8.3

29.4

21.1

5.327

7.564

5.612

7.969

5.777

8.203

5.973

8.482

6.093

8.652

6.176

8.771

8.9

23.9

15.0

6.333

8.993

6.651

9.444

6.910

9.813

7.307

10.376

7.590

10.778

7.801

11.078

8.9

26.7

17.8

5.888

8.361

6.127

8.700

6.301

8.948

6.554

9.306

6.731

9.558

6.863

9.745

8.9

29.4

20.6

5.435

7.718

5.702

8.096

5.861

8.323

6.058

8.603

6.182

8.779

6.270

8.904

Condenser DTb

7.80

6.24

5.20

3.90

3.12

2.60

a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature

b Condenser DT = Leaving Condenser Water Temperature (C) - Entering Condenser Water Temperature ©

c All NPLV values shown are NPLV except at conditions of 15.3 L/MIN-Kw Condenser Flow Rate with 6.7°C Leaving Chilled Water
Temperature and 29.4 C Entering Condenser Water Temperature which is IPLV

Kadj = 6.17568 - 0.303668(X) + 0.00629466(X)2 - 0.000045780(X)3

where X = Condenser DT + LIFT

kw/tonadj = COP * Kadj

Table C-9 (supersedes Table 6.2.1M in ASHRAE/IESNA Standard 90.1)

Column B Minimum Efficiencies for Centrifugal Chillers >527 kW, and <1055 kW (SI)

full load COP std =

5.504

IPLV COP std =

7.816

Condenser Flow Rate

10.2

l/min-kW

12.7

l/min-kW

15.3

l/min-kW

20.4

l/min-kW

25.5

l/min-kW

30.6

l/min-kW

Leaving
Chilled
Water
Temp
(C)

Entering
Condenser
Water
Temp
(C)

Lifta
(F)

FL
COP

NPLV
COP

FL
COP

NPLV
COP

FL
COP

NPLV
COP

FL
COP

NPLV
COP

FL
COP

NPLV

COP

FL
COP

NPLV
COP

4.4

23.9

19.4

5.629

7.994

5.872

8.338

6.029

8.561

6.238

8.857

6.377

9.055

6.478

9.198

4.4

26.7

22.2

5.081

7.215

5.415

7.689

5.600

7.952

5.806

8.244

5.924

8.411

6.002

8.523

4.4

29.4

25.0

4.222

5.996

4.754

6.751

5.037

7.153

5.329

7.568

5.479

7.780

5.570

7.909

5.0

23.9

18.9

5.718

8.120

5.956

8.457

6.116

8.684

6.335

8.996

6.485

9.209

6.595

9.364

5.0

26.7

21.7

5.209

7.397

5.517

7.834

5.690

8.080

5.890

8.363

6.007

8.531

6.088

8.644

5.0

29.4

24.4

4.428

6.288

4.912

6.974

5.170

7.341

5.437

7.721

5.576

7.918

5.662

8.040

5.6

23.9

18.3

5.804

8.242

6.040

8.577

6.206

8.812

6.440

9.145

6.603

9.376

6.723

9.546

5.6

26.7

21.1

5.327

7.564

5.612

7.969

5.777

8.203

5.973

8.482

6.093

8.652

6.176

8.771

5.6

29.4

23.9

4.615

6.554

5.055

7.178

5.290

7.512

5.537

7.863

5.668

8.048

5.750

8.164

6.1

23.9

17.8

5.888

8.361

6.127

8.700

6.301

8.948

6.554

9.306

6.731

9.558

6.863

9.745

6.1

26.7

20.6

5.435

7.718

5.702

8.096

5.861

8.323

6.058

8.603

6.182

8.779

6.270

8.904

6.1

29.4

23.3

4.785

6.795

5.186

7.364

5.401

7.670

5.631

7.996

5.755

8.172

5.835

8.285

6.7

23.9

17.2

5.972

8.480

6.218

8.829

6.404

9.093

6.678

9.482

6.872

9.758

7.017

9.964

6.7

26.7

20.0

5.535

7.860

5.788

8.219

5.945

8.442

6.146

8.727

6.276

8.912

6.370

9.045

6.7

29.4

22.8

4.940

7.015

5.305

7.533

5.504

7.816

5.720

8.123

5.840

8.293

5.918

8.404

7.2

23.9

16.7

6.057

8.600

6.314

8.966

6.514

9.250

6.814

9.675

7.027

9.978

7.186

10.204

7.2

26.7

19.4

5.629

7.994

5.872

8.338

6.029

8.561

6.238

8.857

6.377

9.055

6.478

9.198

7.2

29.4

22.2

5.081

7.215

5.415

7.689

5.600

7.952

5.806

8.244

5.924

8.411

6.002

8.523

7.8

23.9

16.1

6.144

8.725

6.417

9.112

6.634

9.421

6.963

9.887

7.197

10.220

7.372

10.468

7.8

26.7

18.9

5.718

8.120

5.956

8.457

6.116

8.684

6.335

8.996

6.485

9.209

6.595

9.364

7.8

29.4

21.7

5.209

7.397

5.517

7.834

5.690

8.080

5.890

8.363

6.007

8.531

6.088

8.644

8.3

23.9

15.6

6.236

8.855

6.529

9.271

6.766

9.608

7.127

10.120

7.385

10.486

7.577

10.759

8.3

26.7

18.3

5.804

8.242

6.040

8.577

6.206

8.812

6.440

9.145

6.603

9.376

6.723

9.546

8.3

29.4

21.1

5.327

7.564

5.612

7.969

5.777

8.203

5.973

8.482

6.093

8.652

6.176

8.771

8.9

23.9

15.0

6.333

8.993

6.651

9.444

6.910

9.813

7.307

10.376

7.590

10.778

7.801

11.078

8.9

26.7

17.8

5.888

8.361

6.127

8.700

6.301

8.948

6.554

9.306

6.731

9.558

6.863

9.745

8.9

29.4

20.6

5.435

7.718

5.702

8.096

5.861

8.323

6.058

8.603

6.182

8.779

6.270

8.904

Condenser DTb

7.80

6.24

5.20

3.90

3.12

2.60

a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature

b Condenser DT = Leaving Condenser Water Temperature (C) - Entering Condenser Water Temperature ©

c All NPLV values shown are NPLV except at conditions of 15.3 L/MIN-Kw Condenser Flow Rate with 6.7°C Leaving Chilled Water
Temperature and 29.4 C Entering Condenser Water Temperature which is IPLV

Kadj = 6.17568 - 0.303668(X) + 0.00629466(X)2 - 0.000045780(X)3

where X = Condenser DT + LIFT

kw/tonadj = COP * Kadj

Table C-10 (supersedes Table 6.2.1N in ASHRAE/IESNA Standard 90.1)

Column B Minimum Efficiencies for Centrifugal Chillers >1055 kW and < 2108 kW (SI)

full load COP std =

5.862

IPLV COP std =

8.792

Condenser Flow Rate

10.2

l/min-kW

12.7

l/min-kW

15.3

l/min-kW

20.4

l/min-kW

25.5

l/min-kW

30.6

l/min-kW

Leaving
Chilled
Water
Temperature
(C)

Entering
Condenser
Water
Temperature
(C)

Lifta
(F)

FL
COP

NPLV
COP

FL
COP

NPLV
COP

FL
COP

NPLV
COP

FL
COP

NPLV
COP

FL
COP

NPLV
COP

FL
COP

NPLV
COP

4.4

23.9

19.4

5.995

8.993

6.254

9.381

6.421

9.632

6.643

9.965

6.791

10.187

6.899

10.348

4.4

26.7

22.2

5.411

8.117

5.767

8.651

5.964

8.946

6.183

9.275

6.309

9.463

6.392

9.588

4.4

29.4

25.0

4.497

6.745

5.063

7.594

5.365

8.047

5.676

8.513

5.835

8.752

5.932

8.898

5.0

23.9

18.9

6.090

9.135

6.343

9.514

6.513

9.770

6.747

10.121

6.906

10.360

7.023

10.535

5.0

26.7

21.7

5.548

8.322

5.875

8.813

6.060

9.090

6.273

9.409

6.398

9.597

6.483

9.725

5.0

29.4

24.4

4.716

7.074

5.231

7.846

5.506

8.258

5.791

8.686

5.938

8.908

6.030

9.045

5.6

23.9

18.3

6.181

9.272

6.433

9.649

6.609

9.914

6.859

10.288

7.032

10.548

7.159

10.739

5.6

26.7

21.1

5.673

8.510

5.977

8.965

6.153

9.229

6.362

9.542

6.489

9.734

6.578

9.867

5.6

29.4

23.9

4.915

7.373

5.384

8.075

5.634

8.452

5.897

8.846

6.036

9.054

6.123

9.185

6.1

23.9

17.8

6.271

9.406

6.525

9.788

6.711

10.066

6.980

10.470

7.169

10.753

7.309

10.963

6.1

26.7

20.6

5.788

8.683

6.072

9.108

6.242

9.364

6.452

9.678

6.584

9.876

6.678

10.017

6.1

29.4

23.3

5.096

7.645

5.523

8.284

5.753

8.629

5.997

8.996

6.129

9.194

6.214

9.321

6.7

23.9

17.2

6.360

9.540

6.622

9.933

6.820

10.230

7.112

10.668

7.319

10.978

7.473

11.209

6.7

26.7

20.0

5.895

8.843

6.164

9.246

6.331

9.497

6.545

9.818

6.684

10.026

6.784

10.176

6.7

29.4

22.8

5.261

7.892

5.650

8.475

5.862

8.793

6.092

9.138

6.219

9.329

6.303

9.454

7.2

23.9

16.7

6.450

9.675

6.724

10.087

6.937

10.406

7.256

10.885

7.484

11.226

7.653

11.480

7.2

26.7

19.4

5.995

8.993

6.254

9.381

6.421

9.632

6.643

9.965

6.791

10.187

6.899

10.348

7.2

29.4

22.2

5.411

8.117

5.767

8.651

5.964

8.946

6.183

9.275

6.309

9.463

6.392

9.588

7.8

23.9

16.1

6.543

9.815

6.834

10.251

7.066

10.598

7.415

11.123

7.665

11.498

7.851

11.777

7.8

26.7

18.9

6.090

9.135

6.343

9.514

6.513

9.770

6.747

10.121

6.906

10.360

7.023

10.535

7.8

29.4

21.7

5.548

8.322

5.875

8.813

6.060

9.090

6.273

9.409

6.398

9.597

6.483

9.725

8.3

23.9

15.6

6.641

9.962

6.953

10.430

7.206

10.809

7.590

11.385

7.865

11.797

8.069

12.104

8.3

26.7

18.3

6.181

9.272

6.433

9.649

6.609

9.914

6.859

10.288

7.032

10.548

7.159

10.739

8.3

29.4

21.1

5.673

8.510

5.977

8.965

6.153

9.229

6.362

9.542

6.489

9.734

6.578

9.867

8.9

23.9

15.0

6.745

10.117

7.083

10.624

7.360

11.039

7.782

11.673

8.084

12.126

8.308

12.462

8.9

26.7

17.8

6.271

9.406

6.525

9.788

6.711

10.066

6.980

10.470

7.169

10.753

7.309

10.963

8.9

29.4

20.6

5.788

8.683

6.072

9.108

6.242

9.364

6.452

9.678

6.584

9.876

6.678

10.017

Condenser DTb

7.80

6.24

5.20

3.90

3.12

2.60

a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature

b Condenser DT = Leaving Condenser Water Temperature (C) - Entering Condenser Water Temperature ©

c All NPLV values shown are NPLV except at conditions of 15.3 L/MIN-Kw Condenser Flow Rate with 6.7°C Leaving Chilled Water
Temperature and 29.4 C Entering Condenser Water Temperature which is IPLV

Kadj = 6.17568 - 0.303668(X) + 0.00629466(X)2 - 0.000045780(X)3

where X = Condenser DT + LIFT

kw/tonadj = COP * Kadj

Table C-11 (supersedes Table 6.2.1O in ASHRAE/IESNA Standard 90.1)

Column B Minimum Efficiencies for Centrifugal Chillers >2108 kW (SI)

full load COP std =

5.961

IPLV COP std =

8.792

Condenser Flow Rate

10.2

l/min-kW

12.7

l/min-kW

15.3

l/min-kW

20.4

l/min-kW

25.5

l/min-kW

30.6

l/min-kW

Leaving
Chilled
Water
Temperature
(C)

Entering
Condenser
Water
Temperature
(C)

Lifta
(F)

FL
COP

NPLV
COP

FL
COP

NPLV
COP

FL
COP

NPLV
COP

FL
COP

NPLV
COP

FL
COP

NPLV
COP

FL
COP

NPLV
COP

4.4

23.9

19.4

6.097

8.993

6.360

9.381

6.530

9.632

6.756

9.965

6.906

10.187

7.016

10.348

4.4

26.7

22.2

5.503

8.117

5.865

8.651

6.065

8.946

6.288

9.275

6.415

9.463

6.500

9.588

4.4

29.4

25.0

4.573

6.745

5.149

7.594

5.456

8.047

5.772

8.513

5.934

8.752

6.032

8.898

5.0

23.9

18.9

6.193

9.135

6.450

9.514

6.624

9.770

6.861

10.121

7.023

10.360

7.142

10.535

5.0

26.7

21.7

5.642

8.322

5.975

8.813

6.163

9.090

6.379

9.409

6.506

9.597

6.593

9.725

5.0

29.4

24.4

4.796

7.074

5.319

7.846

5.599

8.258

5.889

8.686

6.039

8.908

6.132

9.045

5.6

23.9

18.3

6.286

9.272

6.542

9.649

6.721

9.914

6.975

10.288

7.151

10.548

7.281

10.739

5.6

26.7

21.1

5.769

8.510

6.078

8.965

6.257

9.229

6.469

9.542

6.599

9.734

6.689

9.867

5.6

29.4

23.9

4.998

7.373

5.475

8.075

5.730

8.452

5.997

8.846

6.138

9.054

6.227

9.185

6.1

23.9

17.8

6.377

9.406

6.636

9.788

6.825

10.066

7.098

10.470

7.290

10.753

7.433

10.963

6.1

26.7

20.6

5.887

8.683

6.175

9.108

6.348

9.364

6.561

9.678

6.696

9.876

6.791

10.017

6.1

29.4

23.3

5.183

7.645

5.616

8.284

5.850

8.629

6.099

8.996

6.233

9.194

6.319

9.321

6.7

23.9

17.2

6.468

9.540

6.734

9.933

6.935

10.230

7.232

10.668

7.443

10.978

7.599

11.209

6.7

26.7

20.0

5.995

8.843

6.269

9.246

6.439

9.497

6.656

9.818

6.798

10.026

6.899

10.176

6.7

29.4

22.8

5.350

7.892

5.746

8.475

5.961

8.793

6.195

9.138

6.325

9.329

6.410

9.454

7.2

23.9

16.7

6.560

9.675

6.838

10.087

7.055

10.406

7.379

10.885

7.611

11.226

7.783

11.480

7.2

26.7

19.4

6.097

8.993

6.360

9.381

6.530

9.632

6.756

9.965

6.906

10.187

7.016

10.348

7.2

29.4

22.2

5.503

8.117

5.865

8.651

6.065

8.946

6.288

9.275

6.415

9.463

6.500

9.588

7.8

23.9

16.1

6.654

9.815

6.950

10.251

7.185

10.598

7.541

11.123

7.795

11.498

7.984

11.777

7.8

26.7

18.9

6.193

9.135

6.450

9.514

6.624

9.770

6.861

10.121

7.023

10.360

7.142

10.535

7.8

29.4

21.7

5.642

8.322

5.975

8.813

6.163

9.090

6.379

9.409

6.506

9.597

6.593

9.725

8.3

23.9

15.6

6.754

9.962

7.071

10.430

7.328

10.809

7.718

11.385

7.998

11.797

8.206

12.104

8.3

26.7

18.3

6.286

9.272

6.542

9.649

6.721

9.914

6.975

10.288

7.151

10.548

7.281

10.739

8.3

29.4

21.1

5.769

8.510

6.078

8.965

6.257

9.229

6.469

9.542

6.599

9.734

6.689

9.867

8.9

23.9

15.0

6.859

10.117

7.203

10.624

7.484

11.039

7.914

11.673

8.221

12.126

8.449

12.462

8.9

26.7

17.8

6.377

9.406

6.636

9.788

6.825

10.066

7.098

10.470

7.290

10.753

7.433

10.963

8.9

29.4

20.6

5.887

8.683

6.175

9.108

6.348

9.364

6.561

9.678

6.696

9.876

6.791

10.017

Condenser DTb

7.80

6.24

5.20

3.90

3.12

2.60

a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature

b Condenser DT = Leaving Condenser Water Temperature (C) - Entering Condenser Water Temperature ©

c All NPLV values shown are NPLV except at conditions of 15.3 L/MIN-Kw Condenser Flow Rate with 6.7°C Leaving Chilled Water
Temperature and 29.4 C Entering Condenser Water Temperature which is IPLV

Kadj = 6.17568 - 0.303668(X) + 0.00629466(X)2 - 0.000045780(X)3

where X = Condenser DT + LIFT

kw/tonadj = COP * Kadj

Table C-12 (supersedes Table 6.8.1D in ASHRAE/IESNA Standard 90.1)

Electrically Operated Packaged Terminal Air Conditioners, Packaged Terminal Heat Pumps, Single Packaged Vertical Air Conditioners, Single Packaged Vertical Heat Pumps,
Room Air Conditioners and Room Air Conditioners Heat Pumps -

Minimum Efficiency Requirements (SI)

Equipment Type

Size Category (Input)

Subcategory or
Rating Condition

Minimum
Efficiency
(SI)

Test
Procedure

PTAC (Cooling Mode)
New Construction

<2.0 kW

35 C DB
Outdoor air

3.49 COPC

ARI 310/380

> 2.0 kW and
<2.9 kW

35 C DB
Outdoor air

3.31 COPC

> 2.9 kW and
< 3.8 kW

35 C DB
Outdoor air

3.14 COPC

> 3.8 kW

35 C DB
Outdoor air

3.48 COPC

PTAC (Cooling Mode)
Replacementb

<2.0 kW

35 C DB
Outdoor air

3.49 COPC

ARI 310/380

> 2.0 kW and
<2.9 kW

35 C DB
Outdoor air

3.31 COPC

> 2.9 kW and
< 3.8 kW

35 C DB
Outdoor air

3.14 COPC

> 3.8 kW

35 C DB
Outdoor air

3.48 COPC

PTHP (Cooling Mode)
New Construction

<2.0 kW

35 C DB
Outdoor air

3.48 COPC

ARI 310/380

> 2.0 kW and
<2.9 kW

35 C DB
Outdoor air

3.48 COPC

> 2.9 kW and
< 3.8 kW

35 C DB
Outdoor air

3.48 COPC

> 3.8 kW

35 C DB
Outdoor air

3.48 COPC

PTHP (Heating Mode)
New Construction

All Capacities

35 C DB
Outdoor air

2.8 COPH

ARI 310/380

PTHP (Cooling Mode)
Replacementb

<2.0 kW

35 C DB
Outdoor air

3.43 COPC

ARI 310/380

> 2.0 kW and
<2.9 kW

35 C DB
Outdoor air

3.25 COPC

> 2.9 kW and
< 3.8 kW

35 C DB
Outdoor air

3.08 COPC

> 3.8 kW

35 C DB
Outdoor air

2.73 COPC

PTHP (Heating Mode)
Replacementb

All Capacities

35 C DB
Outdoor air

2.8 COPH

ARI 310/380

Table C-12 (supersedes Table 6.8.1D in ASHRAE/IESNA Standard 90.1) (continued)
Electrically Operated Packaged Terminal Air Conditioners, Packaged Terminal Heat Pumps, Single Packaged Vertical Air Conditioners, Single Packaged Vertical Heat Pumps,
Room Air Conditioners and Room Air Conditioners Heat Pumps -

Minimum Efficiency Requirements (SI)

Equipment Type

Size Category (Input)

Subcategory or
Rating Condition

Minimum
Efficiency

Test
Procedure

SPVAC (Cooling Mode)

<19 kW

35 C DB/23.9 C WB
Outdoor Air

3.81 SCOPC

ARI 390

> 19 kW and < 40 kW Btu/h

35 C DB/23.9 C WB
Outdoor Air

3.37 COPC

> 40kW and < 70 kW

35 C DB/23.9 C WB
Outdoor Air

3.37 COPC

SPVHP (Cooling Mode)

<19 kW

35 C DB/23.9 C WB
Outdoor Air

3.81 SCOPC

> 19 kW and < 40 kW Btu/h

35 C DB/23.9 C WB
Outdoor Air

3.37 COPC

> 40kW and < 70 kW

35 C DB/23.9 C WB
Outdoor Air

3.37 COPC

SPVHP (Heating Mode)

<19 kW

8.3 CF DB/6.1 C WB
Outdoor Air

3.0 COPH

> 19 kW and < 40 kW Btu/h

8.3 CF DB/6.1 C WB
Outdoor Air

3.0 COPH

> 40kW and < 70 kW

8.3 CF DB/6.1 C WB
Outdoor Air

2.9 COPH

Room Air Conditioners,
with louvered Sides

<1.8 kW

3.14 SCOPC

ANSI/
AHAM
RAC-1

>1.8 kW and < 2.3 kW

3.14 COPC

>2.3 kW and <4.1 kW

3.17 COPC

>4.1 kW and < 5.9 kW

3.14 COPC

>5.9 kW

2.73 COPC

Room Air Conditioners,
without Louvered Sides

<2.3 kW

2.90 COPC

>2.3 kW and < 5.9 kW

2.73 COPC

>5.9 kW

2.73 COPC

Room Air Conditioner Heat Pump with
Louvered Sides

<5.9 kW

2.90 COPC

>5.9 kW

2.73 COPC

Room Air Conditioner Heat Pump
without
Louvered Sides

<4.1 kW

2.73 COPC

>4.1 kW

2.58 COPC

Room Air Conditioner,
Casement Only

All Capacities

2.81 COPC

Room Air Conditioner,
Casement-Slider

All Capacities

3.05 COPC

a Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

b Replacement units shall be factory labeled as follows: “MANUFACTURED FOR REPLACEMENT APPLICATIONS ONLY; NOT TO BE INSTALLED IN NEW CONSTRUCTION PROJECTS.” Replacement efficiencies apply only to units with existing sleeves less than 40.6 cm high and less than 106.7 cm wide."

c Cap means the rated cooling capacity of the product in Btu/h. If the unit’s capacity is less than 2.05 kW, use 2.05 kW in the calculation. If the unit’s capacity is greater than 4.39 kW, use 4.39 kW in the calculation."

TABLE C-13 (supersedes Table 6.8.1E in ASHRAE/IESNA Standard 90.1)

Warm Air Furnace and Combustion Warm Air Furnaces/Air Conditioning Units,

Warm Air Duct Furnaces and Unit Heaters (SI)

Equipment Type

Size Category
(Input)

Subcategory or
Rating Condition

Test Procedureb

Minimum
Efficiencya

Warm Air Furnace, Gas-
Fired
(Outdoor Installation)

<65.9 kW

DOE 10 CFR Part
430
or ANSI Z21.47

78% AFUE or
80% Etd,f

>65.9 kW

Maximum
Capacitye

ANSI Z21.47

80% Ecc

Warm Air Furnace, Gas-
Fired
(Indoor Installation)

<65.9 kW

DOE 10 CFR Part
430
or ANSI Z21.47

90% AFUE or
92% Etd,f

>65.9 kW

Maximum
Capacitye

ANSI Z21.47

92% Ecc

Warm Air Furnace,
Oil Fired
(outdoor installation)

<65.9 kW

DOE 10 CFR Part
430
or UL 727

78% AFUE or
80% Etd,f

>65.9 kW

Maximum
Capacitye

UL 727

81% Etf

Warm Air Furnace,
Oil Fired
(indoor installation)

<65.9 kW

DOE 10 CFR Part
430
or UL 727

90% AFUE or
92% Etd,f

>65.9 kW

Maximum
Capacitye

UL 727

92% Etf

Warm Air duct Furnaces,
Gas-Fired
(outdoor installation)

All Capacities

Maximum
Capacitye

ANSI Z83.9

80% Ecg

Warm Air duct Furnaces,
Gas-Fired
(indoor installation)

All Capacities

Maximum

Capacitye

ANSI Z83.9

90% Ecg

Warm Air Unit Heaters,
Gas Fired
(indoor installation)

All Capacities

Maximum
Capacitye

ANSI Z83.8

90% Ecg,h

Warm Air Unit Heaters, Oil
Fired
(indoor installation)

All Capacities

Maximum
Capacitye

UL 731

90% Ecg,h

a Et = thermal efficiency. See test procedure for detailed discussions

b Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of
the test procedure

c Ec = combustion efficiency. Units shall also include an interrupted or intermittent ignition device (IID), have jacket

losses not exceeding 0.75% of the input rating, and have either power venting or flue damper. A vent damper is an
acceptable alternative to the fuel damper for those furnaces where combustion air is drawn from the conditioned space.

d Combustion units not covered by NAECA (3-phase power or cooling capacity greater than or equal to 19.0 kW) may
comply with either rating

e Minimum and maximum ratings as provided for and allowed by the unit's controls

f Et = combustion efficiency. Units shall also include an interrupted or intermittent ignition device (IID), have jacket losses
not exceeding 0.75% of the input rating, and have either power venting or flue damper. A vent damper is an acceptable
alternative to the fuel damper for those furnaces where combustion air is drawn from the conditioned space.

g Ec = combustion efficiency (100% less flue losses) See test procedures for detailed discussion

h As of August 8, 2008, according to the Energy Policy Act of 2005, units shall also include an interrupted or intermittent
ignition devices (IID) and have either power venting or automatic flue dampers. A vent damper is an acceptable
alternative to a flue damper for those unit heaters where combustion air is drawn from the conditioned space.

Table C-14 (supersedes Table 6.8.1F in ASHRAE/IESNA Standard 90.1)

Gas and Oil Fired Boilers - Minimum Efficiency Requirements (SI)

Equipment Type

Subcategory
or
Rating
Condition

Size Category
(Input)

Efficiency

Test Procedure

Boilers, hot water

Gas Fired

<87.9 kW

89 % AFUE

10 CFR Part
430

=87.9 kW and
<732.7 kWd

89% Et

10 CFR Part
431

=732.7 kWa

91% Ec

Oil Firede

<87.9 kW

89 % AFUE

10 CFR Part
430

=87.9 kW and
<732.7 kWd

89% Et

10 CFR Part
431

=732.7 kWa

91% Ec

Boilers, steam

Gas Fired

<87.9 kW

75% AFUE

10 CFR Part
430

Gas fired
all, except
natural draft

=87.9 kW and
<732.7 kWd

79% Et

10 CFR Part
431

=732.7 kWa

79% Et

Gas-fired
natural draft

=87.9 kW and
<732.7 kWd

77% Et

=732.7 kWa

77% Et

Oil Firede

<87.9 kW

80% Et

10 CFR Part
430

=87.9 kW and
<732.7 kWd

81% Et

10 CFR Part
431

=732.7 kWa

81% Et

a These requirements apply to boilers with rated input of 2,344 kW or less that are not packaged
boilers, and to all packaged boilers. Minimum efficiency requirements for boilers cover all
capacities of packaged boilers.

b Ec = thermal efficiency (100% less flue losses). See reference document for detailed information.

c Et = thermal efficiency. See reference document for detailed information.

d Maximum capacity - minimum and maximum ratings as provided for and allowed by the unit's
controls

e Includes oil fired (residual)

f Systems shall be designed with lower operating return hot water temperatures (<55 C) and use hot
water reset to take advantage of the higher efficiencies of condensing boilers

Table C-15 (supersedes Table 6.8.1G in ASHRAE/IESNA Standard 90.1)

Performance Requirements for Heat Rejection Equipment (SI)

Equipment Type

Total System
Heat Rejection
Capacity at
Rated
Conditions

Rating Standard

Rating Conditions

(Annual Cooling Design,
ASHRAE Standard 169,
Table A1, Column 10c)

Performance
Requireda,b

Full Load
Maximum
Approach c

Open loop
Propeller or Axial
Fan Cooling
Towers

All

CTI ATC-105
and CTI STD-
201

1.0 % Design
Evaporation WB
temperature

>4.06 L/s

kW

3.3 C above 1.0% Design Evaporation WB temperature

Closed Loop Propeller or Axial Fan Cooling Towers

All

CTI ATC-105

and CTI STD-201

1.0 % Design Evaporation WB temperature

>1.52 L/s
kW

4.4 C above 1.0% Design Evaporation WB temperature

Open Loop Centrifugal Fan Cooling Towers

All

CTI ATC-105 and CTI STD-201

1.0% Design Evaporation WB temperature

>2.23 L/s

kW

3.3 C above 1.0%
Design
Evaporation WB
temperature

Closed Loop
Centrifugal Fan
Cooling Towers

All

CTI ATC-105

and CTI STD-
201

1.0 % Design
Evaporation WB
temperature

>0.81 L/s
kW

4.4 C above 1.0%
Design
Evaporation WB
temperature

Air-Cooled
Condensers

All

ARI 460

not applicable, air cooled
condenser shall be matched to the
HVAC system and rated per tables
C3

A For purposes of this table, cooling tower performance is defined as the maximum flow rating of the tower divided
by the fan nameplate rated motor power.

B For purposes of this table, air-cooled condenser performance is defined as the heat rejected from the refrigerant
divided by the fan nameplate rated motor power.

C The approach is the design tower leaving water temperature - the building 1.0 % annual cooling design
Evaporation WB temperature from ASHRAE Standard 169, Table A1, Column 10c.

Table C-16 (supersedes Table 6.8.2A in ASHRAE/IESNA Standard 90.1)

Minimum Duct Insulation R-Valuea

Cooling and Heating Only Supply Ducts and Return Ducts (SI)

Climate
Zone

Duct Location

Exterior

Ventilated
Attic

Unvented Attic
Above Insulated
Ceiling

Unvented Attic
with Roof
Insulationa

Unconditioned
Spaceb

Indirectly
Conditioned
Spacec

Buried

Heating
Ducts
Only

Heating Ducts Only

1, 2

none

none

none

none

none

none

none

3

R-1.06

none

none

none

R-1.06

none

none

4

R-1.06

none

none

none

R-1.06

none

none

5

R-1.41

R-1.06

none

none

R 1.06

none

R-1.06

6

R-1.41

R-1.41

R-1.06

none

R 1.06

none

R-1.06

7

R-1.76

R-1.41

R-1.41

none

R-1.06

none

R-1.06

8

R-1.76

R-10

R-1.41

none

R-1.41

none

R-1.41

Cooling
Only
Ducts

Cooling Only Ducts

1

R-1.06

R-1.41

R-10

R-1.06

R-1.06

none

R-1.06

2

R-1.06

R-1.41

R-10

R-1.06

R-1.06

none

R-1.06

3

R-1.06

R-1.41

R-1.41

R-1.06

R-0.62

none

none

4

R-0.62

R-1.06

R-1.41

R-0.62

R-0.62

none

none

5, 6

R-0.62

R-0.62

R-1.06

R-0.62

R-0.62

none

none

7, 8

R-1.9

R-0.62

R-0.62

R-0.62

R-0.62

none

none

Return
Ducts

Return Ducts

1 to 8

R-1.06

R-1.06

R-1.06

none

none

none

none

a Insulation R-values, measured in m2 k/kW, are for the insulation as installed and do not include film resistance. The
required minimum thicknesses do not consider water vapor transmission and possible surface condensation.
Where exterior walls are used as plenum walls, wall insulation shall be as required by the most restrictive
condition of 6.4.4.2 or Section 5. Insulation resistance measured on a horizontal plane in accordance with ASTM
C518 at a mean temperature of 23.8 C at the installed thickness.

b Includes crawl spaces, both ventilated and non-ventilated.

c Includes return air plenums with or without exposed roofs above.

Table C-17 (supersedes Table 6.8.2B in ASHRAE/IESNA Standard 90.1)

Minimum Duct Insulation R-Valuea,

Combined Heating and Cooling Supply Ducts and Return Ducts (SI)

Climate
Zone

Duct Location

Exterior

Ventilated
Attic

Unvented Attic
Above Insulated
Ceiling

Unvented
Attic w/ Roof
Insulationa

Unconditioned
Spaceb

Indirectly
Conditioned
Spacec

Buried

Supply Ducts

1

R-1.41

R-1.41

R-1.76

R-1.06

R-1.06

none

R-1.06

2

R-1.41

R-1.41

R-1.41

R-1.06

R-1.41

none

R-1.06

3

R-1.41

R-1.41

R-1.41

R-1.06

R-1.41

none

R-1.06

4

R-1.41

R-1.41

R-1.41

R-1.06

R-1.41

none

R-1.06

5

R-1.41

R-1.41

R-1.41

R-0.62

R-1.41

none

R-1.06

6

R-1.76

R-1.41

R-1.41

R-0.62

R-1.41

none

R-1.06

7

R-1.76

R-1.41

R-1.41

R-0.62

R-1.41

none

R-1.06

8

R-1.76

R-1.94

R-1.94

R-0.62

R-1.41

none

R-1.41

Return Ducts

1 to 8

R-1.06

R-1.06

R-1.06

none

none

none

none

"a Insulation R-values, measured in m2 k/kW, are for the insulation as installed and do not include film resistance. The
required minimum thicknesses do not consider water vapor transmission and possible surface condensation.
Where exterior walls are used as plenum walls, wall insulation shall be as required by the most restrictive
condition of 6.4.4.2 or Section 5. Insulation resistance measured on a horizontal plane in accordance with ASTM
C518 at a mean temperature of 23.8 C at the installed thickness."

b Includes crawl spaces, both ventilated and non-ventilated.

c Includes return air plenums with or without exposed roofs above.

Table C-18 (supersedes Table 6.8.3 in ASHRAE/IESNA Standard 90.1)

Minimum Pipe Insulation Thicknessa (SI)

Fluid Design
Operating Temp.
Range (°C)

Insulation Conductivity

Nominal Pipe or Tube Size (mm)

Conductivity
kW/(h-m2
°K)

Mean
Rating
Temp.
°C

<25

25 to < 38

38 to <
102

102 to
<203

>203

Heating Systems (Steam, Steam Condensate, and Hot Water)b,c

>176.7

1.82-1.93

121.1

76

89

89

114

114

121.7-176.7

1.65-1.82

200

51

76

89

89

89

93.9-121.1

1.53-1.70

150

51

51

63

63

63

60.6-93.3

1.42-1.65

125

38

38

38

51

51

40.6-60.0

1.25-1.59

100

25

25

38

38

38

Domestic and Service Hot Water Systems

40.6+

1.25-1.59

100

25

25

38

38

38

Cooling Systems (Chilled Water, Brine, and Refrigerant)d

4.4-15.6

1.25-1.59

100

25

25

38

38

38

<4.4

1.25-1.59

100

25

38

38

38

51

a For insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows:

$T = r\{(1 + t/r)K/k - 1\}$

where T = minimum insulation thickness (mm), r = actual outside radius of pipe (mm), t = insulation thickness listed in
this table for applicable fluid temperature and pipe size, K = conductivity of alternate material at mean rating
temperature indicated for the applicable fluid temperature (kW/(h-m2 K); and k= the upper value of the conductivity
range listed in this table for the applicable fluid temperature.

b These thicknesses are based on energy efficiency considerations only. Additional insulation is sometimes required
relative to safety issues/surface temperature.

c Piping insulation is not required between the control valve and coil on run-outs when the

control valve is located within 1.2 m of the coil and the pipe size is 25 mm or less."

d These thicknesses are based on energy efficiency considerations only. Issues such as water vapor permeability or
surface condensation sometimes require vapor retarders or additional insulation.

Table C-19 (supersedes Table 7.8 in ASHRAE/IESNA Standard 90.1)

Performance Requirements for Water Heating Equipment (SI)

Equipment Type

Size Category
(Input)

Subcategory or
Rating Condition

Performance Required a

Test
Procedure b

Electric Water
Heaters

12 kW

Resistance > 75.7L

0.93-0.00132V EF

DOE 10 CFR
Part 430

>12 kW

Resistance > 75.7L

20 + 35 V.5 SL, Btu/h

ANSI Z21.10.3

24 Amps and
< 250 volts

Heat Pump

0.93-0.00132V EF

DOE 10 CFR
Part 430

Gas Storage Water
Heaters

<75,000 Btu/h

Resistance > 75.7L

0.62-0.0019V EF

DOE 10 CFR
Part 430

>75,000 Btu/h

<310.1 (kW/L)

80% Et (Q/800 + 110 V.5) SL, Btu/h

ANSI Z21.10.3

Gas Instantaneous Water
Heaters

>50,000 Btu/h
and <2000,000
Btu/h

> 310.1 kWQ/L
and < 7.56 L

0.62-0.0019V EF

DOE 10 CFR
Part 430

> 200,000 Btu/hc

> 310.1 kWQ/L
and < 37.8 L

80% Et

ANSI Z21.10.3

>200,000 Btu/h

> 310.1 kWQ/L
and < 37.8 L

80% Et (Q/800 + 110 V.5) SL, Btu/h

Oil Storage Water Heaters

<105,000 Btu/h

Resistance > 75.7L

0.59-0.0019V EF

DOE 10 CFR
Part 430

>105,000 Btu/h

<310.1 (kW/L)

78% Et (Q/800 + 110 V.5) SL, Btu/h

ANSI Z21.10.3

Oil Instantaneous Water
Heaters

< 210,000 Btu/h

> 310.1 kWQ/L
and < 7.56 L

0.59-0.0019V EF

DOE 10 CFR
Part 430

>210,000 Btu/h

> 310.1 kWQ/L
and < 37.8 L

80% Et

ANSI Z21.10.3

>210,000 Btu/h

> 310.1 kWQ/L
and < 37.8 L

78% Et (Q/800 + 110 V.5) SL, Btu/h

Hot Water Supply Boilers,
Gas and Oil

 300,000 Btu/h
and <12,500,000
Btu/h

> 310.1 kWQ/L
and < 37.8 L

80% Et

ANSI Z21.10.3

Hot Water Supply
Boilers, Gas

> 310.1 kWQ/L
and < 37.8 L

80% Et (Q/800 + 110 V.5) SL, Btu/h

Hot Water Supply
Boilers, Oil

> 310.1 kWQ/L
and < 37.8 L

78% Et (Q/800 + 110 V.5) SL, Btu/h

Pool Heaters

OIl and Gas

All

78% Et

ASHRAE 146

Heat Pump Pool Heaters

All

4.0 COP

ASHRAE 146

Unfired Storage
Tanks

All

R-12.5

(none)

"a Energy factor (EF) and thermal efficiency (Et) are minimum requirements, while standby loss (SL) is maximum kW
based

on a 21.1 C temperature difference between stored water and ambient requirements. In the EF equation, V is the
rated volume

in gallons. In the SL equation, V is the rated volume in gallons and Q is the nameplate input rate in kW b Section 12 contains a complete specification, including the year version, of the referenced test procedure.

c Instantaneous water heaters with input rates below 58.6 kW shall comply with these requirements if the water
heater is

designed to heat water to temperatures 82.2°C or higher."

TABLE C-20 Minimum Nominal Efficiency

for General Purpose Design A and Design B Motorsa (SI)

Minimum Nominal Full-Load Efficiency (%)

Open Motors

Enclosed Motors

Number of Poles ==>

2

4

6

2

4

6

Synchronous Speed (RPM)
==>

3600

1800

1200

3600

1800

1200

Motor Size (kW)

0.7

77.0

85.5

82.5

77.0

85.5

82.5

1.1

84.0

86.5

86.5

84.0

86.5

87.5

1.5

85.5

86.5

87.5

85.5

86.5

88.5

2.2

85.5

89.5

88.5

86.5

89.5

89.5

3.7

86.5

89.5

89.5

88.5

89.5

89.5

5.6

88.5

91.0

90.2

89.5

91.7

91.0

7.5

89.5

91.7

91.7

90.2

91.7

91.0

11.2

90.2

93.0

91.7

91.0

92.4

91.7

14.9

91.0

93.0

92.4

91.0

93.0

91.7

18.7

91.7

93.6

93.0

91.7

93.6

93.0

22.4

91.7

94.1

93.6

91.7

93.6

93.0

29.8

92.4

94.1

94.1

92.4

94.1

94.1

37.3

93.0

94.5

94.1

93.0

94.5

94.1

44.8

93.6

95.0

94.5

93.6

95.0

94.5

56.0

93.6

95.0

94.5

93.6

95.4

94.5

74.6

93.6

95.4

95.0

94.1

95.4

95.0

93.3

94.1

95.4

95.0

95.0

95.4

95.0

111.9

94.1

95.8

95.4

95.0

95.8

95.8

149.2

95.0

95.8

95.4

95.4

96.2

95.8

186.5

95.0

95.8

95.4

95.8

96.2

95.8

223.8

95.4

95.8

95.4

95.8

96.2

95.8

261.1

95.4

95.8

95.4

95.8

96.2

95.8

298.4

95.8

95.8

95.8

95.8

96.2

95.8

335.7

95.8

96.2

96.2

95.8

96.2

95.8

373.0

95.8

96.2

96.2

95.8

96.2

95.8

a Nominal efficiencies shall be established in accordance with NEMA Standard MG1. Design A and Design B are National Electric Manufacturers Association (NEMA) design class designations for fixed frequency small and medium AC squirrel-cage induction motors.

Table C-21 – Transformer Minimum Efficiences (SI)

Rated Capacity
(kVA)

600 Volts or lessa

Single Phase

10

--

15

97.7

25

98.0

37.5

98.2

50

98.3

75

98.5

100

98.6

167

98.7

250

98.8

333

98.9

3 Phase

15

97.0

30

97.5

45

97.7

75

98.0

112.5

98.2

150

98.3

225

98.5

300

98.6

500

98.7

750

98.8

1000

98.9

a Ratings are based on the DOE Test Procedure defined in Part 431 section 323 (B)(10) and 346(a) at a rating
temperature of 75 C and a load of 35% of the nameplate load

Table C-22 Commercial Refrigerator & Freezers (SI)

Equipment Type	Application	Energy Use Limit (kW/h per day)
Refrigerators with solid doors	holding temperature	2.831 V + 57.75
Refrigerators with transparent doors		3.40 V + 94.55
Freezers with solid doors		11.32 V + 39.07
Freezers with transparent doors		21.23 V + 116.07
Refrigerators/freezers with solid doors		the greater of 3.40 V + 94.55 or 19.82
Commercial Refrigerators	pulldown	1.26 V + 99.37

V means the chiller or frozen compartment volume (Liters) as defined in the Association of Home Appliance manufacturers Standard HRF1-1979

Table C-23 Commercial Clothes Washers (SI)

Product	MER	WF
All Commercial Clothes Washers	48.6932	30.28

MER = Modified Energy Factor, a combination of Energy Factor and MEF=Modified Energy Factor, a combination of Energy Factor and Remaining Moisture Content. MEF measures energy consumption of the total laundry cycle (washing and drying). It indicates how many liters of laundry can be washed and dried with one kWh of electricity; the higher the number, the greater the efficiency.

Table C-1 (supersedes Table 6.8.1A in ASHRAE/IESNA Standard 90.1) –

Electrical Operated Unitary Air Conditioners and Condensing Units (I-P)

Equipment Type

Size Category

Heating Section
Type

Sub-Category or
Rating Conditions

Minimum
Efficiency

Test Procedure

Air Conditioners,
Air Cooled

<65,000 Btu/h

All

Split Systems

14.0 SEER
12.0 EER

ARI 210/240

Single Packaged

14.0 SEER
11.6 EER

ARI 210/240

Through-the-wall Air

Cooled

<30,000 Btu/h

All

Split Systems

12.0 SEER

ARI 210/240

Single Packaged

12.0 SEER

ARI 210/240

Small-Duct High
Velocity,
Air-Cooled

<65,000 Btu/h

All

Split Systems

10 SEER

ARI 210/240

Air Conditioners,
Air Cooled

>65,000 Btu/h and
< 135,000 Btu/h

Electric Resistance
(or None)

Split Systems and
Single Package

11.5 EER
12.0 IEER

ARI 340/360

All other

Split Systems and
Single Package

11.3 EER
11.8 IEER

ARI 340/360

>135,000 Btu/h and
< 240,000 Btu/h

Electric Resistance
(or None)

Split Systems and
Single Package

11.5 EER
12.0 IEER

ARI 340/360

All other

Split Systems and
Single Package

11.3 EER
11.8 IEER

ARI 340/360

>240,000 Btu/h and
< 760,000 Btu/h

Electric Resistance
(or None)

Split Systems and
Single Package

10.0 EER
10.5 IEER

ARI 340/360

All other

Split Systems and
Single Package

9.8 EER
10.3 IEER

ARI 340/360

>760,000 Btu/h

Electric Resistance
(or None)

Split Systems and
Single Package

9.7 EER
10.2 IEER

ARI 340/360

All other

Split Systems and
Single Package

9.5 EER
10.0 IEER

ARI 340/360

Table C-1 (supersedes Table 6.8.1A in ASHRAE/IESNA Standard 90.1) –

Electrical Operated Unitary Air Conditioners and Condensing Units (I-P) (continued)

Equipment Type	Size Category	Heating Section Type	Sub-Category or Rating Conditions	Minimum Efficiency	Test Procedure
Air Conditioners, Water and Evaporatively Cooled	<65,000 Btu/h	All	Split Systems and Single Package	14.0 EER 14.3 IEER	ARI 210/240
	>65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)			

Split Systems and
Single Package

14.0 EER
14.3 IEER

ARI 340/360

All other

Split Systems and
Single Package

13.8 EER
14.1 IEER

ARI 340/360

>135,000 Btu/h and
< 240,000 Btu/h

Electric Resistance
(or None)

Split Systems and
Single Package

14.0 EER
14.3 IEER

ARI 340/360

All other

Split Systems and
Single Package

13.8 EER
14.1 IEER

ARI 340/360

>240,000 Btu/h

Electric Resistance
(or None)

Split Systems and
Single Package

14.0 EER
14.0 IEER

ARI 340/360

All other

Split Systems and
Single Package

13.8 EER
13.8 IEER

ARI 340/360

Condensing Units,
Air Cooled

>135,000 Btu/h

not applicable
match with indoor
coil

ARI 365

Condensing, Water or
Evaporatively Cooled

>135,000 Btu/h

not applicable
match with indoor
coil

ARI 365

Table C-2 (supersedes Table 6.8.1B in ASHRAE/IESNA Standard 90.1) –

Electrically Operated Unitary and Applied Heat Pumps
Minimum Efficiency Requirements (I-P)

Equipment Type

Size Category

Heating Section
Type

Sub-Category or
Rating Conditions

Minimum
Efficiency

Test Procedure

Air Conditioners,
Air Cooled
(Cooling Mode)

<65,000 Btu/h

All

Split Systems

14.0 SEER
12.0 EER

ARI 210/240

Single Packaged

14.0 SEER
11.6 EER

Through-the-wall Air
Cooled
(Cooling Mode)

<30,000 Btu/h

All

Split Systems

12.0 SEER

Single Packaged

12.0 SEER

Small-Duct High
Velocity,
Air-Cooled
(Cooling Mode)

<65,000 Btu/h

All

Split Systems

10.0 SEER

Air Conditioners,
Air Cooled
(Cooling Mode)

>65,000 Btu/h and
< 135,000 Btu/h

Electric Resistance
(or None)

Split Systems and
Single Package

11.3 EER
11.8 IEER

ARI 340/360

All other

Split Systems and
Single Package

11.1 EER
11.6 IEER

>135,000 Btu/h and
< 240,000 Btu/h

Electric Resistance
(or None)

Split Systems and
Single Package

11.3 EER
11.8 IEER

All other

Split Systems and
Single Package

11.1 EER
11.6 IEER

>240,000 Btu/h

Electric Resistance
(or None)

Split Systems and
Single Package

9.8 EER
9.8 IEER

All other

Split Systems and
Single Package

9.6 EER
9.6 IEER

Water-Source

(Cooling Mode)

<17,000 Btu/h

All

86°F Entering Water

14.0 EER

ISO-13256-1

>17,000 Btu/h and
< 65,000 Btu/h

All

86°F Entering Water

14.0 EER

>65,000 Btu/h and
< 135,000 Btu/h

All

86°F Entering Water

14.0 EER

Groundwater-Source
(Cooling Mode)

< 135,000 Btu/h

All

59°F Entering Water

16.2 EER

All

77°F Entering Water

13.4 EER

Table C-2 (supersedes Table 6.8.1B in ASHRAE/IESNA Standard 90.1) –

Electrically Operated Unitary and Applied Heat Pumps
Minimum Efficiency Requirements (I-P) (continued)

Equipment Type	Size Category	Heating Section Type	Sub-Category or Rating Conditions	Minimum Efficiency	Test Procedure
Air Conditioners, Air Cooled (Heating Mode)	<65,000 Btu/h	All	Split Systems	8.5 HSPF	ARI210/240
			Single Packaged	8.0 HSPF	
Through-the-wall Air Cooled (Heating Mode)	<30,000 Btu/h				

All

Split Systems

7.4 HSPF

Single Packaged

7.4 HSPF

Small-Duct High
Velocity,
Air-Cooled
(Heating Mode)

<65,000 Btu/h

All

Split Systems

6.8 HSPF

Air Cooled
(Heating Mode)

>65,000 Btu/h and
<135,000 Btu/h
(Cooling Capacity)

47°F DB/43°F WB
Outdoor Air

3.3 COP

ARI 340/360

17°F DB/15°F WB
Outdoor Air

2.2 COP

>135,000 Btu/h

(Cooling Capacity)

47°F DB/43°F WB
Outdoor Air

3.2 COP

17°F DB/15°F WB
Outdoor Air

2.0 COP

Water-Source
(Heating Mode)

< 135,000 Btu/h
(Cooling Capacity)

68°F Entering Water

4.2 COP

ISO-13256-1

Groundwater-Source
(Heating Mode)

< 135,000 Btu/h
(Cooling Capacity)

50°F Entering Water

3.6 COP

32°F Entering Fluid

3.1 COP

Table C-3 (supersedes Table 6.8.1C in ASHRAE/IESNA Standard 90.1)

Water Chilling Packages – Minimum Efficiency Requirements (I-P)

Equipment Type

Size Category

Units

Minimum Efficiency (I-P)

Test Procedure

Path A

Path B

Full Load

IPLV

Full Load

IPLV

Air Cooled Chillers with Condenser, Electrically Operated

<150 tons

EER

10.000

12.500

NA

NA

ARI 550/590

>150 tons

EER

10.000

12.750

NA

NA

Air Cooled without
Condenser, Electrical
Operated

All Capacities

EER

condenserless units shall be rated with matched
condensers

ARI 550/590

Water cooled, Electrically
Operated, Positive
Displacement
(Reciprocating)

All Capacities

kw/ton

reciprocating units required to comply with water cooled
positive displacement requirements

ARI 550/590

Water Cooled Electrically
Operated, Positive
Displacement

<75 tons

kw/ton

0.780

0.630

0.800

0.600

ARI 550/590

>75 tons and <
150 tons

kw/ton

0.775

0.615

0.790

0.586

>150 tons and <
300 tons

kw/ton

0.680

0.580

0.718

0.540

>300 tons

kw/ton

0.620

0.540

0.639

0.490

Water Cooled Electrically
Operated, Centrifugal

<150 tons

kw/ton

0.634

0.596

0.639

0.450

ARI 550/590

>150 tons and <
300 tons

kw/ton

0.634

0.596

0.639

0.450

>300 tons and <
600 tons

kw/ton

0.576

0.549

0.600

0.400

>600 tons

kw/ton

0.570

0.539

0.590

0.400

Air Cooled Absorption
Single Effecth

All Capacities

COP

0.600

NR

NA

NA

ARI 560

Water-Cooled Absorption
Single Effecth

All Capacities

COP

0.700

NR

NA

NA

Absorption Double Effect

Indirect-Fired

All Capacities

COP

1.000

1.050

NA

NA

Absorption Double Effect
Direct Fired

All Capacities

COP

1.000

1.000

NA

NA

a. The chiller equipment requirements do not apply for chillers used in low-temperature applications where the design
leaving fluid temperature is <40°F

b Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of
the test procedure

c. Where there is a Column A and Column B requirement either column can be used for compliance, but both the full and
IPLV values shall be complied with

d. Path A is intended for applications where significant operating time is expected at full load and design ambient

e. Path B is intended for applications with significant operating time at part load. All path B machines shall be equipped
with demand limiting capable controls

f. NA means that this requirement is not applicable and can not be used for compliance

g. NR means that for this category there are no minimum requirements

h. Only allowed to be used in heat recovery applications

Table C-4 (supersedes Table 6.2.1H in ASHRAE/IESNA Standard 90.1)

Column A Minimum Efficiencies for Centrifugal Chillers <150 tons (I-P)

full load kw/ton std = 0.634

IPLV kw/ton std = 0.596

Condenser Flow Rate

2 gpm/ton

2.5 gpm/ton

3 gpm/ton

4 gpm/ton

5 gpm/ton

6 gpm/ton

Leaving
Chilled
Water
Temp.(F)

Entering
Cond
Water
Temp. (F)

Lifta
(F)

FL
kW/Ton

NPLV

kW/ton

FL
kW/Ton

NPLV
kW/ton

FL
kW/Ton

NPLV
kW/ton

FL
kW/Ton

NPLV
kW/ton

FL
kW/Ton

NPLV
kW/ton

FL
kW/Ton

NPLV
kW/ton

40

75

35

0.620

0.583

0.594

0.559

0.579

0.544

0.559

0.526

0.547

0.514

0.539

0.506

40

80

40

0.687

0.646

0.644

0.606

0.623

0.586

0.601

0.565

0.589

0.554

0.581

0.547

40

85

45

0.826

0.777

0.734

0.690

0.693

0.651

0.655

0.616

0.637

0.599

0.626

0.589

41

75

34

0.610

0.574

0.586

0.551

0.571

0.536

0.551

0.518

0.538

0.506

0.529

0.497

41

80

39

0.670

0.630

0.633

0.595

0.613

0.576

0.592

0.557

0.581

0.546

0.573

0.539

41

85

44

0.788

0.741

0.710

0.668

0.675

0.635

0.642

0.603

0.626

0.588

0.616

0.579

42

75

33

0.601

0.565

0.578

0.543

0.562

0.529

0.542

0.509

0.529

0.497

0.519

0.488

42

80

38

0.655

0.616

0.622

0.585

0.604

0.568

0.584

0.549

0.573

0.538

0.565

0.531

42

85

43

0.756

0.711

0.690

0.649

0.660

0.620

0.630

0.592

0.616

0.579

0.607

0.571

43

75

32

0.593

0.557

0.570

0.535

0.554

0.521

0.532

0.501

0.518

0.487

0.508

0.478

43

80

37

0.642

0.604

0.612

0.575

0.595

0.560

0.576

0.541

0.564

0.531

0.557

0.523

43

85

42

0.729

0.685

0.673

0.633

0.646

0.607

0.620

0.583

0.606

0.570

0.598

0.562

44

75

31

0.584

0.549

0.561

0.528

0.545

0.512

0.523

0.491

0.508

0.477

0.497

0.468

44

80

36

0.630

0.593

0.603

0.567

0.587

0.552

0.568

0.534

0.556

0.523

0.548

0.515

44

85

41

0.706

0.664

0.658

0.618

0.634

0.596

0.610

0.573

0.598

0.562

0.590

0.554

45

75

30

0.576

0.542

0.553

0.520

0.536

0.504

0.512

0.481

0.497

0.467

0.486

0.456

45

80

35

0.620

0.583

0.594

0.559

0.579

0.544

0.559

0.526

0.547

0.514

0.539

0.506

45

85

40

0.687

0.646

0.644

0.606

0.623

0.586

0.601

0.565

0.589

0.554

0.581

0.547

46

75

29

0.568

0.534

0.544

0.511

0.526

0.494

0.501

0.471

0.485

0.456

0.473

0.445

46

80

34

0.610

0.574

0.586

0.551

0.571

0.536

0.551

0.518

0.538

0.506

0.529

0.497

46

85

39

0.670

0.630

0.633

0.595

0.613

0.576

0.592

0.557

0.581

0.546

0.573

0.539

47

75

28

0.560

0.526

0.534

0.502

0.516

0.485

0.490

0.460

0.473

0.444

0.461

0.433

47

80

33

0.601

0.565

0.578

0.543

0.562

0.529

0.542

0.509

0.529

0.497

0.519

0.488

47

85

38

0.655

0.616

0.622

0.585

0.604

0.568

0.584

0.549

0.573

0.538

0.565

0.531

48

75

27

0.551

0.518

0.525

0.493

0.505

0.475

0.478

0.449

0.460

0.432

0.447

0.420

48

80

32

0.593

0.557

0.570

0.535

0.554

0.521

0.532

0.501

0.518

0.487

0.508

0.478

48

85

37

0.642

0.604

0.612

0.575

0.595

0.560

0.576

0.541

0.564

0.531

0.557

0.523

Condenser DTb

14.04

11.23

9.36

7.02

5.62

4.68

a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature

b Condenser DT = Leaving Condenser Water Temperature (°F) - Entering Condenser Water Temperature (°F)

c All NPLV values shown are NPLV except at conditions of 3 gpm/ton Condenser Flow Rate with 44°F Leaving Chilled
Water Temperature and 85°F Entering Condenser Water Temperature which is IPLV

$$K_{adj} = 6.17568 - 0.303668(X) + 0.00629466(X)^2 - 0.000045780(X)^3$$

where X = Condenser DT + LIFT

$$kw/ton_{adj} = (kw/ton)/K_{adj}$$

Table C-5 (supersedes Table 6.2.1I in ASHRAE/IESNA Standard 90.1)

Column A Minimum Efficiencies for Centrifugal Chillers >150 tons, <300 tons (I-P)

full load kw/ton std =

0.634

IPLV kw/ton std

0.596

Condenser Flow Rate

2

gpm/ton

2.5

gpm/ton

3

gpm/ton

4

gpm/ton

5

gpm/ton

6

gpm/ton

Leaving
Chilled
Water

Temp (F)

Entering
Cond
Water
Temp (F)

Lifta
(F)

FL
kW/Ton

IPLV
kW/ton

FL
kW/Ton

IPLV
kW/ton

FL
kW/Ton

IPLV
kW/ton

FL
kW/Ton

IPLV
kW/ton

FL
kW/Ton

IPLV
kW/ton

FL
kW/Ton

IPLV
kW/ton

40

75

35

0.620

0.583

0.594

0.559

0.579

0.544

0.559

0.526

0.547

0.514

0.539

0.506

40

80

40

0.687

0.646

0.644

0.606

0.623

0.586

0.601

0.565

0.589

0.554

0.581

0.547

40

85

45

0.826

0.777

0.734

0.690

0.693

0.651

0.655

0.616

0.637

0.599

0.626

0.589

41

75

34

0.610

0.574

0.586

0.551

0.571

0.536

0.551

0.518

0.538

0.506

0.529

0.497

41

80

39

0.670

0.630

0.633

0.595

0.613

0.576

0.592

0.557

0.581

0.546

0.573

0.539

41

85

44

0.788

0.741

0.710

0.668

0.675

0.635

0.642

0.603

0.626

0.588

0.616

0.579

42

75

33

0.601

0.565

0.578

0.543

0.562

0.529

0.542

0.509

0.529

0.497

0.519

0.488

42

80

38

0.655

0.616

0.622

0.585

0.604

0.568

0.584

0.549

0.573

0.538

0.565

0.531

42

85

43

0.756

0.711

0.690

0.649

0.660

0.620

0.630

0.592

0.616

0.579

0.607

0.571

43

75

32

0.593

0.557

0.570

0.535

0.554

0.521

0.532

0.501

0.518

0.487

0.508

0.478

43

80

37

0.642

0.604

0.612

0.575

0.595

0.560

0.576

0.541

0.564

0.531

0.557

0.523

43

85

42

0.729

0.685

0.673

0.633

0.646

0.607

0.620

0.583

0.606

0.570

0.598

0.562

44

75

31

0.584

0.549

0.561

0.528

0.545

0.512

0.523

0.491

0.508

0.477

0.497

0.468

44

80

36

0.630

0.593

0.603

0.567

0.587

0.552

0.568

0.534

0.556

0.523

0.548

0.515

44

85

41

0.706

0.664

0.658

0.618

0.634

0.596

0.610

0.573

0.598

0.562

0.590

0.554

45

75

30

0.576

0.542

0.553

0.520

0.536

0.504

0.512

0.481

0.497

0.467

0.486

0.456

45

80

35

0.620

0.583

0.594

0.559

0.579

0.544

0.559

0.526

0.547

0.514

0.539

0.506

45

85

40

0.687

0.646

0.644

0.606

0.623

0.586

0.601

0.565

0.589

0.554

0.581

0.547

46

75

29

0.568

0.534

0.544

0.511

0.526

0.494

0.501

0.471

0.485

0.456

0.473

0.445

46

80

34

0.610

0.574

0.586

0.551

0.571

0.536

0.551

0.518

0.538

0.506

0.529

0.497

46

85

39

0.670

0.630

0.633

0.595

0.613

0.576

0.592

0.557

0.581

0.546

0.573

0.539

47

75

28

0.560

0.526

0.534

0.502

0.516

0.485

0.490

0.460

0.473

0.444

0.461

0.433

47

80

33

0.601

0.565

0.578

0.543

0.562

0.529

0.542

0.509

0.529

0.497

0.519

0.488

47

85

38

0.655

0.616

0.622

0.585

0.604

0.568

0.584

0.549

0.573

0.538

0.565

0.531

48

75

27

0.551

0.518

0.525

0.493

0.505

0.475

0.478

0.449

0.460

0.432

0.447

0.420

48

80

32

0.593

0.557

0.570

0.535

0.554

0.521

0.532

0.501

0.518

0.487

0.508

0.478

48

85

37

0.642

0.604

0.612

0.575

0.595

0.560

0.576

0.541

0.564

0.531

0.557

0.523

Condenser DTb

14.04

11.23

9.36

7.02

5.62

4.68

a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature b Condenser DT = Leaving Condenser Water Temperature (°F) - Entering Condenser Water Temperature (°F)

c All NPLV values shown are NPLV except at conditions of 3 gpm/ton Condenser Flow Rate with 44°F Leaving Chilled
Water Temperature and 85°F Entering Condenser Water Temperature which is IPLV

Kadj = 6.17568 - 0.303668(X) + 0.00629466(X)2 - 0.000045780(X)3

where X = Condenser DT + LIFT

kw/tonadj = (kw/ton)/Kadj

Table C-6 (supersedes Table 6.2.1J in ASHRAE/IESNA Standard 90.1)

Column A Minimum Efficiencies for Centrifugal Chillers >300 tons, <600 tons (I-P)

full load kw/ton std =

0.576

IPLV kw/ton std =

0.549

Condenser Flow Rate

2

gpm/ton

2.5

gpm/ton

3

gpm/ton

4

gpm/ton

5

gpm/ton

6

gpm/ton

Leaving
Chilled
Water
Temp (F)

Entering
Cond
Water
Temp (F)

Lifta
(F)

FL
kW/Ton

IPLV
kW/ton

FL
kW/Ton

IPLV
kW/ton

FL
kW/Ton

IPLV
kW/ton

FL
kW/Ton

IPLV
kW/ton

FL
kW/Ton

IPLV

kW/ton

FL
kW/Ton

IPLV
kW/ton

40

75

35

0.563

0.537

0.540

0.515

0.526

0.501

0.508

0.484

0.497

0.474

0.489

0.466

40

80

40

0.624

0.595

0.585

0.558

0.566

0.540

0.546

0.520

0.535

0.510

0.528

0.503

40

85

45

0.751

0.716

0.667

0.636

0.629

0.600

0.595

0.567

0.579

0.552

0.569

0.542

41

75

34

0.554

0.528

0.532

0.507

0.518

0.494

0.500

0.477

0.489

0.466

0.481

0.458

41

80

39

0.609

0.580

0.575

0.548

0.557

0.531

0.538

0.513

0.528

0.503

0.521

0.496

41

85

44

0.716

0.682

0.645

0.615

0.613

0.585

0.583

0.556

0.569

0.542

0.560

0.534

42

75

33

0.546

0.521

0.525

0.500

0.511

0.487

0.492

0.469

0.480

0.458

0.472

0.449

42

80

38

0.595

0.567

0.565

0.538

0.549

0.523

0.531

0.506

0.520

0.496

0.513

0.489

42

85

43

0.687

0.655

0.627

0.598

0.599

0.571

0.573

0.546

0.559

0.533

0.551

0.526

43

75

32

0.538

0.513

0.517

0.493

0.503

0.480

0.484

0.461

0.471

0.449

0.462

0.440

43

80

37

0.583

0.556

0.556

0.530

0.541

0.516

0.523

0.499

0.513

0.489

0.506

0.482

43

85

42

0.662

0.631

0.611

0.583

0.587

0.559

0.563

0.537

0.551

0.525

0.543

0.518

44

75

31

0.531

0.506

0.510

0.486

0.495

0.472

0.475

0.452

0.461

0.440

0.452

0.431

44

80

36

0.573

0.546

0.548

0.522

0.533

0.508

0.516

0.492

0.505

0.481

0.498

0.474

44

85

41

0.642

0.612

0.598

0.570

0.576

0.549

0.554

0.528

0.543

0.517

0.536

0.511

45

75

30

0.523

0.499

0.502

0.479

0.487

0.464

0.465

0.443

0.451

0.430

0.441

0.420

45

80

35

0.563

0.537

0.540

0.515

0.526

0.501

0.508

0.484

0.497

0.474

0.489

0.466

45

85

40

0.624

0.595

0.585

0.558

0.566

0.540

0.546

0.520

0.535

0.510

0.528

0.503

46

75

29

0.516

0.492

0.494

0.471

0.478

0.455

0.455

0.434

0.440

0.420

0.430

0.410

46

80

34

0.554

0.528

0.532

0.507

0.518

0.494

0.500

0.477

0.489

0.466

0.481

0.458

46

85

39

0.609

0.580

0.575

0.548

0.557

0.531

0.538

0.513

0.528

0.503

0.521

0.496

47

75

28

0.508

0.485

0.486

0.463

0.469

0.447

0.445

0.424

0.429

0.409

0.418

0.399

47

80

33

0.546

0.521

0.525

0.500

0.511

0.487

0.492

0.469

0.480

0.458

0.472

0.449

47

85

38

0.595

0.567

0.565

0.538

0.549

0.523

0.531

0.506

0.520

0.496

0.513

0.489

48

75

27

0.501

0.477

0.477

0.454

0.459

0.437

0.434

0.414

0.418

0.398

0.406

0.387

48

80

32

0.538

0.513

0.517

0.493

0.503

0.480

0.484

0.461

0.471

0.449

0.462

0.440

48

85

37

0.583

0.556

0.556

0.530

0.541

0.516

0.523

0.499

0.513

0.489

0.506

0.482

Condenser DTb

14.04

11.23

9.36

7.02

5.62

4.68

a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature

b Condenser DT = Leaving Condenser Water Temperature (°F) - Entering Condenser Water Temperature (°F)

c All NPLV values shown are NPLV except at conditions of 3 gpm/ton Condenser Flow Rate with 44°F Leaving Chilled Water
Temperature and 85°F Entering Condenser Water Temperature which is IPLV

$K_{adj} = 6.17568 - 0.303668(X) + 0.00629466(X)^2 - 0.000045780(X)^3$

where X = Condenser DT + LIFT

$kw/ton_{adj} = (kw/ton)/K_{adj}$

Table C-7 (supersedes Table 6.2.1K in ASHRAE/IESNA Standard 90.1)

Column A Minimum Efficiencies for Centrifugal Chillers >600 tons (I-P)

full load kw/ton std =

0.570

IPLV kw/ton std =

0.539

Condenser Flow Rate

2

gpm/ton

2.5

gpm/ton

3

gpm/ton

4

gpm/ton

5

gpm/ton

6

gpm/ton

Leaving
Chilled
Water
Temp (F)

Entering
Cond
Water
Temp (F)

Lifta
(F)

FL
kW/Ton

IPLV
kW/ton

FL
kW/Ton

IPLV
kW/ton

FL
kW/Ton

IPLV
kW/ton

FL
kW/Ton

IPLV
kW/ton

FL
kW/Ton

IPLV

kW/ton

FL
kW/Ton

IPLV
kW/ton

40

75

35

0.557

0.527

0.534

0.505

0.520

0.492

0.503

0.476

0.492

0.465

0.484

0.458

40

80

40

0.617

0.584

0.579

0.548

0.560

0.530

0.540

0.511

0.530

0.501

0.523

0.494

40

85

45

0.743

0.703

0.660

0.624

0.623

0.589

0.589

0.557

0.573

0.541

0.563

0.533

41

75

34

0.549

0.519

0.527

0.498

0.513

0.485

0.495

0.468

0.484

0.457

0.476

0.450

41

80

39

0.602

0.569

0.569

0.538

0.551

0.521

0.533

0.504

0.522

0.494

0.515

0.487

41

85

44

0.708

0.670

0.639

0.604

0.607

0.574

0.577

0.546

0.563

0.532

0.554

0.524

42

75

33

0.541

0.511

0.519

0.491

0.506

0.478

0.487

0.461

0.475

0.449

0.467

0.441

42

80

38

0.589

0.557

0.559

0.529

0.543

0.514

0.525

0.497

0.515

0.487

0.508

0.480

42

85

43

0.680

0.643

0.621

0.587

0.593

0.561

0.567

0.536

0.554

0.523

0.546

0.516

43

75

32

0.533

0.504

0.512

0.484

0.498

0.471

0.479

0.453

0.466

0.441

0.457

0.432

43

80

37

0.577

0.546

0.550

0.520

0.535

0.506

0.518

0.490

0.507

0.480

0.500

0.473

43

85

42

0.656

0.620

0.605

0.572

0.581

0.549

0.557

0.527

0.545

0.515

0.538

0.508

44

75

31

0.525

0.497

0.505

0.477

0.490

0.463

0.470

0.444

0.457

0.432

0.447

0.423

44

80

36

0.567

0.536

0.542

0.513

0.528

0.499

0.510

0.483

0.500

0.473

0.492

0.466

44

85

41

0.635

0.601

0.591

0.559

0.570

0.539

0.548

0.519

0.537

0.508

0.530

0.501

45

75

30

0.518

0.490

0.497

0.470

0.482

0.455

0.460

0.435

0.446

0.422

0.437

0.413

45

80

35

0.557

0.527

0.534

0.505

0.520

0.492

0.503

0.476

0.492

0.465

0.484

0.458

45

85

40

0.617

0.584

0.579

0.548

0.560

0.530

0.540

0.511

0.530

0.501

0.523

0.494

46

75

29

0.511

0.483

0.489

0.462

0.473

0.447

0.451

0.426

0.436

0.412

0.426

0.402

46

80

34

0.549

0.519

0.527

0.498

0.513

0.485

0.495

0.468

0.484

0.457

0.476

0.450

46

85

39

0.602

0.569

0.569

0.538

0.551

0.521

0.533

0.504

0.522

0.494

0.515

0.487

47

75

28

0.503

0.476

0.481

0.454

0.464

0.438

0.440

0.416

0.425

0.402

0.414

0.392

47

80

33

0.541

0.511

0.519

0.491

0.506

0.478

0.487

0.461

0.475

0.449

0.467

0.441

47

85

38

0.589

0.557

0.559

0.529

0.543

0.514

0.525

0.497

0.515

0.487

0.508

0.480

48

75

27

0.495

0.468

0.472

0.446

0.454

0.429

0.429

0.406

0.413

0.391

0.402

0.380

48

80

32

0.533

0.504

0.512

0.484

0.498

0.471

0.479

0.453

0.466

0.441

0.457

0.432

48

85

37

0.577

0.546

0.550

0.520

0.535

0.506

0.518

0.490

0.507

0.480

0.500

0.473

Condenser DTb

14.04

11.23

9.36

7.02

5.62

4.68

a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature

b Condenser DT = Leaving Condenser Water Temperature (°F) - Entering Condenser Water Temperature (°F)

c All NPLV values shown are NPLV except at conditions of 3 gpm/ton Condenser Flow Rate with 44°F Leaving Chilled Water
Temperature and 85°F Entering Condenser Water Temperature which is IPLV

Kadj = 6.17568 - 0.303668(X) + 0.00629466(X)2 - 0.000045780(X)3

where X = Condenser DT + LIFT

kw/tonadj = (kw/ton)/Kadj

Table C-8 (supersedes Table 6.2.1L in ASHRAE/IESNA Standard 90.1)

Column B Minimum Efficiencies for Centrifugal Chillers <150 tons (I-P)

full load kw/ton std =

0.639

IPLV kw/ton std =

0.450

Condenser Flow Rate

2

gpm/ton

2.5

gpm/ton

3

gpm/ton

4

gpm/ton

5

gpm/ton

6

gpm/ton

Leaving
Chilled
Water
Temp (F)

Entering Con-
denser Water
Temp
(F)

Lifta
(F)

FL
kW/Ton

IPLV
kW/ton

FL
kW/Ton

IPLV
kW/ton

FL
kW/Ton

IPLV
kW/ton

FL
kW/Ton

IPLV
kW/ton

FL
kW/Ton

IPLV

kW/ton

FL
kW/Ton

IPLV
kW/ton

40

75

35

0.625

0.440

0.599

0.422

0.583

0.411

0.564

0.397

0.552

0.388

0.543

0.382

40

80

40

0.692

0.487

0.649

0.457

0.628

0.442

0.606

0.427

0.594

0.418

0.586

0.413

40

85

45

0.833

0.587

0.740

0.521

0.698

0.492

0.660

0.465

0.642

0.452

0.631

0.445

41

75

34

0.615

0.433

0.591

0.416

0.575

0.405

0.555

0.391

0.542

0.382

0.533

0.376

41

80

39

0.675

0.475

0.638

0.449

0.618

0.435

0.597

0.421

0.585

0.412

0.578

0.407

41

85

44

0.794

0.559

0.716

0.504

0.680

0.479

0.647

0.456

0.631

0.444

0.621

0.437

42

75

33

0.606

0.427

0.582

0.410

0.567

0.399

0.546

0.385

0.533

0.375

0.523

0.368

42

80

38

0.660

0.465

0.627

0.441

0.609

0.429

0.589

0.415

0.577

0.406

0.569

0.401

42

85

43

0.762

0.537

0.696

0.490

0.665

0.468

0.635

0.447

0.621

0.437

0.612

0.431

43

75

32

0.597

0.421

0.574

0.404

0.558

0.393

0.537

0.378

0.523

0.368

0.512

0.361

43

80

37

0.647

0.456

0.617

0.434

0.600

0.423

0.581

0.409

0.569

0.401

0.561

0.395

43

85

42

0.735

0.518

0.678

0.478

0.651

0.459

0.625

0.440

0.611

0.430

0.603

0.425

44

75

31

0.589

0.415

0.566

0.398

0.549

0.387

0.527

0.371

0.512

0.360

0.501

0.353

44

80

36

0.635

0.447

0.608

0.428

0.592

0.417

0.572

0.403

0.560

0.395

0.552

0.389

44

85

41

0.712

0.501

0.663

0.467

0.639

0.450

0.615

0.433

0.602

0.424

0.594

0.419

45

75

30

0.581

0.409

0.557

0.392

0.540

0.380

0.516

0.364

0.500

0.352

0.489

0.345

45

80

35

0.625

0.440

0.599

0.422

0.583

0.411

0.564

0.397

0.552

0.388

0.543

0.382

45

85

40

0.692

0.487

0.649

0.457

0.628

0.442

0.606

0.427

0.594

0.418

0.586

0.413

46

75

29

0.572

0.403

0.548

0.386

0.530

0.373

0.505

0.356

0.489

0.344

0.477

0.336

46

80

34

0.615

0.433

0.591

0.416

0.575

0.405

0.555

0.391

0.542

0.382

0.533

0.376

46

85

39

0.675

0.475

0.638

0.449

0.618

0.435

0.597

0.421

0.585

0.412

0.578

0.407

47

75

28

0.564

0.397

0.539

0.379

0.520

0.366

0.494

0.348

0.476

0.335

0.464

0.327

47

80

33

0.606

0.427

0.582

0.410

0.567

0.399

0.546

0.385

0.533

0.375

0.523

0.368

47

85

38

0.660

0.465

0.627

0.441

0.609

0.429

0.589

0.415

0.577

0.406

0.569

0.401

48

75

27

0.555

0.391

0.529

0.372

0.509

0.358

0.481

0.339

0.463

0.326

0.451

0.317

48

80

32

0.597

0.421

0.574

0.404

0.558

0.393

0.537

0.378

0.523

0.368

0.512

0.361

48

85

37

0.647

0.456

0.617

0.434

0.600

0.423

0.581

0.409

0.569

0.401

0.561

0.395

Condenser DTb

14.04

11.23

9.36

7.02

5.62

4.68

a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature

b Condenser DT = Leaving Condenser Water Temperature (°F) - Entering Condenser Water Temperature (°F)

c All NPLV values shown are NPLV except at conditions of 3 gpm/ton Condenser Flow Rate with 44°F Leaving Chilled Water
Temperature and 85°F Entering Condenser Water Temperature which is IPLV

$K_{adj} = 6.17568 - 0.303668(X) + 0.00629466(X)^2 - 0.000045780(X)^3$

where X = Condenser DT + LIFT

$kw/ton_{adj} = (kw/ton)/K_{adj}$

Table C-9 (supersedes Table 6.2.1M in ASHRAE/IESNA Standard 90.1)

Column B Minimum Efficiencies for Centrifugal Chillers >150 tons, <300 tons (I-P)

full load kw/ton std =

0.639

IPLV kw/ton std =

0.450

Condenser Flow Rate

2

gpm/ton

2.5

gpm/ton

3

gpm/ton

4

gpm/ton

5

gpm/ton

6

gpm/ton

Leaving
Chilled
Water
Temp (F)

Entering
Condenser
Water Temp
(F)

Lifta
(F)

FL
kW/Ton

IPLV
kW/ton

FL
kW/Ton

IPLV
kW/ton

FL
kW/Ton

IPLV
kW/ton

FL
kW/Ton

IPLV
kW/ton

FL
kW/Ton

IPLV

kW/ton

FL
kW/Ton

IPLV
kW/ton

40

75

35

0.625

0.440

0.599

0.422

0.583

0.411

0.564

0.397

0.552

0.388

0.543

0.382

40

80

40

0.692

0.487

0.649

0.457

0.628

0.442

0.606

0.427

0.594

0.418

0.586

0.413

40

85

45

0.833

0.587

0.740

0.521

0.698

0.492

0.660

0.465

0.642

0.452

0.631

0.445

41

75

34

0.615

0.433

0.591

0.416

0.575

0.405

0.555

0.391

0.542

0.382

0.533

0.376

41

80

39

0.675

0.475

0.638

0.449

0.618

0.435

0.597

0.421

0.585

0.412

0.578

0.407

41

85

44

0.794

0.559

0.716

0.504

0.680

0.479

0.647

0.456

0.631

0.444

0.621

0.437

42

75

33

0.606

0.427

0.582

0.410

0.567

0.399

0.546

0.385

0.533

0.375

0.523

0.368

42

80

38

0.660

0.465

0.627

0.441

0.609

0.429

0.589

0.415

0.577

0.406

0.569

0.401

42

85

43

0.762

0.537

0.696

0.490

0.665

0.468

0.635

0.447

0.621

0.437

0.612

0.431

43

75

32

0.597

0.421

0.574

0.404

0.558

0.393

0.537

0.378

0.523

0.368

0.512

0.361

43

80

37

0.647

0.456

0.617

0.434

0.600

0.423

0.581

0.409

0.569

0.401

0.561

0.395

43

85

42

0.735

0.518

0.678

0.478

0.651

0.459

0.625

0.440

0.611

0.430

0.603

0.425

44

75

31

0.589

0.415

0.566

0.398

0.549

0.387

0.527

0.371

0.512

0.360

0.501

0.353

44

80

36

0.635

0.447

0.608

0.428

0.592

0.417

0.572

0.403

0.560

0.395

0.552

0.389

44

85

41

0.712

0.501

0.663

0.467

0.639

0.450

0.615

0.433

0.602

0.424

0.594

0.419

45

75

30

0.581

0.409

0.557

0.392

0.540

0.380

0.516

0.364

0.500

0.352

0.489

0.345

45

80

35

0.625

0.440

0.599

0.422

0.583

0.411

0.564

0.397

0.552

0.388

0.543

0.382

45

85

40

0.692

0.487

0.649

0.457

0.628

0.442

0.606

0.427

0.594

0.418

0.586

0.413

46

75

29

0.572

0.403

0.548

0.386

0.530

0.373

0.505

0.356

0.489

0.344

0.477

0.336

46

80

34

0.615

0.433

0.591

0.416

0.575

0.405

0.555

0.391

0.542

0.382

0.533

0.376

46

85

39

0.675

0.475

0.638

0.449

0.618

0.435

0.597

0.421

0.585

0.412

0.578

0.407

47

75

28

0.564

0.397

0.539

0.379

0.520

0.366

0.494

0.348

0.476

0.335

0.464

0.327

47

80

33

0.606

0.427

0.582

0.410

0.567

0.399

0.546

0.385

0.533

0.375

0.523

0.368

47

85

38

0.660

0.465

0.627

0.441

0.609

0.429

0.589

0.415

0.577

0.406

0.569

0.401

48

75

27

0.555

0.391

0.529

0.372

0.509

0.358

0.481

0.339

0.463

0.326

0.451

0.317

48

80

32

0.597

0.421

0.574

0.404

0.558

0.393

0.537

0.378

0.523

0.368

0.512

0.361

48

85

37

0.647

0.456

0.617

0.434

0.600

0.423

0.581

0.409

0.569

0.401

0.561

0.395

Condenser DTb

14.04

11.23

9.36

7.02

5.62

4.68

a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature

b Condenser DT = Leaving Condenser Water Temperature (°F) - Entering Condenser Water Temperature (°F)

c All NPLV values shown are NPLV except at conditions of 3 gpm/ton Condenser Flow Rate with 44°F Leaving Chilled Water
Temperature and 85°F Entering Condenser Water Temperature which is IPLV

Kadj = 6.17568 - 0.303668(X) + 0.00629466(X)2 - 0.000045780(X)3

where X = Condenser DT + LIFT

kw/tonadj = (kw/ton)/Kadj

Table C-10 (supersedes Table 6.2.1N in ASHRAE/IESNA Standard 90.1)

Column B Minimum Efficiencies for Centrifugal Chillers >300 tons, <600 tons (I-P)

full load kw/ton std =

0.600

IPLV kw/ton std =

0.400

Condenser Flow Rate

2

gpm/ton

2.5

gpm/ton

3

gpm/ton

4

gpm/ton

5

gpm/ton

6

gpm/ton

Leaving
Chilled
Water
Temp (F)

Entering
Condenser
Water Temp
(F)

Lifta
(F)

FL
kW/Ton

IPLV
kW/ton

FL
kW/Ton

IPLV
kW/ton

FL
kW/Ton

IPLV
kW/ton

FL
kW/Ton

IPLV
kW/ton

FL
kW/Ton

IPLV
kW/ton

FL
kW/Ton

IPLV
kW/ton

40

75

35

0.587

0.391

0.562

0.375

0.548

0.365

0.529

0.353

0.518

0.345

0.510

0.340

40

80

40

0.650

0.433

0.610

0.407

0.590

0.393

0.569

0.379

0.557

0.372

0.550

0.367

40

85

45

0.782

0.521

0.695

0.463

0.656

0.437

0.620

0.413

0.603

0.402

0.593

0.395

41

75

34

0.577

0.385

0.554

0.370

0.540

0.360

0.521

0.348

0.509

0.339

0.501

0.334

41

80

39

0.634

0.423

0.599

0.399

0.580

0.387

0.561

0.374

0.550

0.366

0.542

0.362

41

85

44

0.746

0.497

0.672

0.448

0.639

0.426

0.607

0.405

0.592

0.395

0.583

0.389

42

75

33

0.569

0.379

0.547

0.364

0.532

0.355

0.513

0.342

0.500

0.333

0.491

0.327

42

80

38

0.620

0.413

0.588

0.392

0.572

0.381

0.553

0.369

0.542

0.361

0.535

0.356

42

85

43

0.716

0.477

0.653

0.436

0.624

0.416

0.596

0.398

0.583

0.388

0.574

0.383

43

75

32

0.561

0.374

0.539

0.359

0.524

0.349

0.504

0.336

0.491

0.327

0.481

0.321

43

80

37

0.608

0.405

0.579

0.386

0.563

0.376

0.545

0.363

0.534

0.356

0.527

0.351

43

85

42

0.690

0.460

0.637

0.425

0.611

0.408

0.586

0.391

0.574

0.383

0.566

0.377

44

75

31

0.553

0.369

0.531

0.354

0.516

0.344

0.495

0.330

0.481

0.320

0.471

0.314

44

80

36

0.597

0.398

0.571

0.380

0.555

0.370

0.537

0.358

0.526

0.351

0.518

0.346

44

85

41

0.668

0.446

0.622

0.415

0.600

0.400

0.577

0.385

0.565

0.377

0.558

0.372

45

75

30

0.545

0.364

0.523

0.349

0.507

0.338

0.485

0.323

0.470

0.313

0.460

0.306

45

80

35

0.587

0.391

0.562

0.375

0.548

0.365

0.529

0.353

0.518

0.345

0.510

0.340

45

85

40

0.650

0.433

0.610

0.407

0.590

0.393

0.569

0.379

0.557

0.372

0.550

0.367

46

75

29

0.537

0.358

0.515

0.343

0.498

0.332

0.474

0.316

0.459

0.306

0.448

0.299

46

80

34

0.577

0.385

0.554

0.370

0.540

0.360

0.521

0.348

0.509

0.339

0.501

0.334

46

85

39

0.634

0.423

0.599

0.399

0.580

0.387

0.561

0.374

0.550

0.366

0.542

0.362

47

75

28

0.530

0.353

0.506

0.337

0.488

0.325

0.463

0.309

0.447

0.298

0.436

0.291

47

80

33

0.569

0.379

0.547

0.364

0.532

0.355

0.513

0.342

0.500

0.333

0.491

0.327

47

85

38

0.620

0.413

0.588

0.392

0.572

0.381

0.553

0.369

0.542

0.361

0.535

0.356

48

75

27

0.521

0.348

0.497

0.331

0.478

0.319

0.452

0.301

0.435

0.290

0.423

0.282

48

80

32

0.561

0.374

0.539

0.359

0.524

0.349

0.504

0.336

0.491

0.327

0.481

0.321

48

85

37

0.608

0.405

0.579

0.386

0.563

0.376

0.545

0.363

0.534

0.356

0.527

0.351

Condenser DTb

14.04

11.23

9.36

7.02

5.62

4.68

a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature

b Condenser DT = Leaving Condenser Water Temperature (°F) - Entering Condenser Water Temperature (°F)

c All NPLV values shown are NPLV except at conditions of 3 gpm/ton Condenser Flow Rate with 44°F Leaving Chilled Water
Temperature and 85°F Entering Condenser Water Temperature which is IPLV

Kadj = 6.17568 - 0.303668(X) + 0.00629466(X)2 - 0.000045780(X)3

where X = Condenser DT + LIFT

kw/tonadj = (kw/ton)/Kadj

Table C-11 (supersedes Table 6.2.1O in ASHRAE/IESNA Standard 90.1)

Column B Minimum Efficiencies for Centrifugal Chillers >600 tons (I-P)

full load kw/ton std =

0.590

IPLV kw/ton std

0.400

Condenser Flow Rate

2

gpm/ton

2.5

gpm/ton

3

gpm/ton

4

gpm/ton

5

gpm/ton

6

gpm/ton

Leaving Chilled
Water
Temperature
(F)

Entering
Condenser
Water Temp
(F)

Lifta
(F)

FL
kW/Ton

IPLV
kW/ton

FL
kW/Ton

IPLV
kW/ton

FL
kW/Ton

IPLV
kW/ton

FL
kW/Ton

IPLV
kW/ton

FL
kW/Ton

IPLV

kW/ton

FL
kW/Ton

IPLV
kW/ton

40

75

35

0.577

0.391

0.553

0.375

0.539

0.365

0.521

0.353

0.509

0.345

0.501

0.340

40

80

40

0.639

0.433

0.600

0.407

0.580

0.393

0.559

0.379

0.548

0.372

0.541

0.367

40

85

45

0.769

0.521

0.683

0.463

0.645

0.437

0.609

0.413

0.593

0.402

0.583

0.395

41

75

34

0.568

0.385

0.545

0.370

0.531

0.360

0.513

0.348

0.501

0.339

0.492

0.334

41

80

39

0.623

0.423

0.589

0.399

0.571

0.387

0.551

0.374

0.541

0.366

0.533

0.362

41

85

44

0.733

0.497

0.661

0.448

0.628

0.426

0.597

0.405

0.582

0.395

0.574

0.389

42

75

33

0.559

0.379

0.538

0.364

0.523

0.355

0.504

0.342

0.492

0.333

0.483

0.327

42

80

38

0.610

0.413

0.579

0.392

0.562

0.381

0.544

0.369

0.533

0.361

0.526

0.356

42

85

43

0.704

0.477

0.642

0.436

0.614

0.416

0.586

0.398

0.573

0.388

0.565

0.383

43

75

32

0.552

0.374

0.530

0.359

0.515

0.349

0.495

0.336

0.482

0.327

0.473

0.321

43

80

37

0.597

0.405

0.570

0.386

0.554

0.376

0.536

0.363

0.525

0.356

0.518

0.351

43

85

42

0.679

0.460

0.626

0.425

0.601

0.408

0.577

0.391

0.564

0.383

0.557

0.377

44

75

31

0.544

0.369

0.522

0.354

0.507

0.344

0.486

0.330

0.473

0.320

0.463

0.314

44

80

36

0.587

0.398

0.561

0.380

0.546

0.370

0.528

0.358

0.517

0.351

0.510

0.346

44

85

41

0.657

0.446

0.612

0.415

0.590

0.400

0.568

0.385

0.556

0.377

0.549

0.372

45

75

30

0.536

0.364

0.514

0.349

0.499

0.338

0.477

0.323

0.462

0.313

0.452

0.306

45

80

35

0.577

0.391

0.553

0.375

0.539

0.365

0.521

0.353

0.509

0.345

0.501

0.340

45

85

40

0.639

0.433

0.600

0.407

0.580

0.393

0.559

0.379

0.548

0.372

0.541

0.367

46

75

29

0.529

0.358

0.506

0.343

0.489

0.332

0.466

0.316

0.451

0.306

0.440

0.299

46

80

34

0.568

0.385

0.545

0.370

0.531

0.360

0.513

0.348

0.501

0.339

0.492

0.334

46

85

39

0.623

0.423

0.589

0.399

0.571

0.387

0.551

0.374

0.541

0.366

0.533

0.362

47

75

28

0.521

0.353

0.497

0.337

0.480

0.325

0.456

0.309

0.440

0.298

0.429

0.291

47

80

33

0.559

0.379

0.538

0.364

0.523

0.355

0.504

0.342

0.492

0.333

0.483

0.327

47

85

38

0.610

0.413

0.579

0.392

0.562

0.381

0.544

0.369

0.533

0.361

0.526

0.356

48

75

27

0.513

0.348

0.488

0.331

0.470

0.319

0.444

0.301

0.428

0.290

0.416

0.282

48

80

32

0.552

0.374

0.530

0.359

0.515

0.349

0.495

0.336

0.482

0.327

0.473

0.321

48

85

37

0.597

0.405

0.570

0.386

0.554

0.376

0.536

0.363

0.525

0.356

0.518

0.351

Condenser DTb

14.04

11.23

9.36

7.02

5.62

4.68

a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature

b Condenser DT = Leaving Condenser Water Temperature (°F) - Entering Condenser Water Temperature (°F)

c All NPLV values shown are NPLV except at conditions of 3 gpm/ton Condenser Flow Rate with 44°F Leaving Chilled Water
Temperature and 85°F Entering Condenser Water Temperature which is IPLV

$K_{adj} = 6.17568 - 0.303668(X) + 0.00629466(X)^2 - 0.000045780(X)^3$

where X = Condenser DT + LIFT

$kw/ton_{adj} = (kw/ton)/K_{adj}$

Table C-12 (supersedes Table 6.8.1D in ASHRAE/IESNA Standard 90.1)

Electrically Operated Packaged Terminal Air Conditioners, Packaged Terminal Heat Pumps, Single Packaged Vertical Air Conditioners, Single Packaged Vertical Heat Pumps,
Room Air Conditioners and Room Air Conditioners Heat Pumps -

Minimum Efficiency Requirements (I-P)

Equipment Type

Size Category (Input)

Subcategory or
Rating Condition

Minimum
Efficiency

Test
Procedure

PTAC (Cooling Mode)
New Construction

<7,000 Btu/h

95°F DB
Outdoor air

11.9 EER

ARI 310/380

> 7,000 Btu/h and
<10,000 Btu/h

95°F DB
Outdoor air

11.3 EER

> 10,000 Btu/h and

< 13,000 Btu/h

95°F DB
Outdoor air

10.7 EER

> 13,000 Btu/h

95°F DB
Outdoor air

9.5 EER

PTAC (Cooling Mode)
Replacementb

<7,000 Btu/h

95°F DB
Outdoor air

11.9 EER

ARI 310/380

> 7,000 Btu/h and
<10,000 Btu/h

95°F DB
Outdoor air

11.3 EER

> 10,000 Btu/h and
< 13,000 Btu/h

95°F DB
Outdoor air

10.7 EER

> 13,000 Btu/h

95°F DB
Outdoor air

9.5 EER

PTHP (Cooling Mode)
New Construction

<7,000 Btu/h

95°F DB
Outdoor air

11.7 EER

ARI 310/380

> 7,000 Btu/h and
<10,000 Btu/h

95°F DB
Outdoor air

11.1 EER

> 10,000 Btu/h and
< 13,000 Btu/h

95°F DB
Outdoor air

10.5 EER

> 13,000 Btu/h

95°F DB
Outdoor air

9.3 EER

PTHP (Heating Mode)
New Construction

All Capacities

95°F DB
Outdoor air

2.8 COP

ARI 310/380

PTHP (Cooling Mode)
Replacementb

<7,000 Btu/h

95°F DB
Outdoor air

11.7 EER

ARI 310/380

> 7,000 Btu/h and
<10,000 Btu/h

95°F DB
Outdoor air

11.1 EER

> 10,000 Btu/h and
< 13,000 Btu/h

95°F DB
Outdoor air

10.5 EER

> 13,000 Btu/h

95°F DB
Outdoor air

9.3 EER

PTHP (Heating Mode)
Replacementb

All Capacities

95°F DB
Outdoor air

2.8 COP

ARI 310/380

Table C-12 (supersedes Table 6.8.1D in ASHRAE/IESNA Standard 90.1) (continued)
Electrically Operated Packaged Terminal Air Conditioners, Packaged Terminal Heat Pumps, Single Packaged Vertical Air Conditioners, Single Packaged Vertical Heat Pumps,
Room Air Conditioners and Room Air Conditioners Heat Pumps -

Minimum Efficiency Requirements (I-P)

Equipment Type

Size Category (Input)

Subcategory or
Rating Condition

Minimum
Efficiency

Test
Procedure

SPVAC (Cooling Mode)

<65,000 Btu/h

95°F DB/75°F WB
Outdoor Air

13.0 SEER

ARI 390

> 65,000 Btu/h and < 135,000 Btu/h

95°F DB/75°F WB
Outdoor Air

11.5 EER

>135,000 Btu/h and <240,000 Btu/h

95°F DB/75°F WB
Outdoor Air

11.5 EER

SPVHP (Cooling Mode)

<65,000 Btu/h

95°F DB/75°F WB
Outdoor Air

13.0 SEER

> 65,000 Btu/h and < 135,000
Btu/h

95°F DB/75°F WB
Outdoor Air

11.5 EER

>135,000 Btu/hr and <240,000
Btu/h

95°F DB/75°F WB
Outdoor Air

11.5 EER

SPVHP (Heating Mode)

<65,000 Btu/h

47°F DB/43°F WB
Outdoor Air

3.0 COP

> 65,000 Btu/h and < 135,000
Btu/h

47°F DB/43°F WB
Outdoor Air

3.0 COP

>135,000 Btu/hr and <240,000
Btu/h

47°F DB/43°F WB
Outdoor Air

2.9 COP

Room Air Conditioners,
with louvered Sides

<6000 Btu/h

10.7 SEER

ANSI/
AHAM
RAC-1

>6000 Btu/h and
<8000 Btu/h

10.7 EER

>8000 Btu/h and
<14,000 Btu/h

10.8 EER

>14000 Btu/h and
<20,000 Btu/h

10.7 EER

>20,000 Btu/h

9.3 EER

Room Air Conditioners,
without Louvered Sides

<8000 Btu/h

9.9 EER

>8000 Btu/h and
<20,000 Btu/h

9.3 EER

>20,000 Btu/h

9.3 EER

Room Air Conditioner Heat Pump with
Louvered Sides

<20,000 Btu/h

9.9 EER

>20,000 Btu/h

9.3 EER

Room Air Conditioner Heat Pump
without
Louvered Sides

<14,000 Btu/h

9.3 EER

>14,000 Btu/h

8.8 EER

Room Air Conditioner,
Casement Only

All Capacities

9.6 EER

Room Air Conditioner,
Casement-Slider

All Capacities

10.4 EER

a Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test
procedure.

b Replacement units shall be factory labeled as follows: “MANUFACTURED FOR REPLACEMENT APPLICATIONS ONLY; NOT TO
BE INSTALLED IN NEW CONSTRUCTION PROJECTS.” Replacement efficiencies apply only to units with existing sleeves less than
16 in. high and less than 42 in. wide."

c Cap means the rated cooling capacity of the product in Btu/h. If the unit’s capacity is less than 7000 Btu/h, use 7000 Btu/h in the
calculation. If the unit’s capacity is greater than 15,000 Btu/h, use 15,000 Btu/h in the calculation."

TABLE C-13 (supersedes Table 6.8.1E in ASHRAE/IESNA Standard 90.1)

Warm Air Furnace and Combustion Warm Air Furnaces/Air Conditioning Units,

Warm Air Duct Furnaces and Unit Heaters (I-P)

Equipment Type

Size Category
(Input)

Subcategory or
Rating Condition

Test Procedureb

Minimum Efficiencya

Warm Air Furnace, Gas-Fired
(Outdoor Installation)

<225,000 Btu/h

DOE 10 CFR Part 430
or ANSI Z21.47

78% AFUE or
80% Etd,f

>225,000 Btu/h

Maximum Capacitye

ANSI Z21.47

80% Ecc

Warm Air Furnace, Gas-Fired
(Indoor Installation)

<225,000 Btu/h

DOE 10 CFR Part 430
or ANSI Z21.47

90% AFUE or
92% Etd,f

>225,000 Btu/h

Maximum Capacitye

ANSI Z21.47

92% Ecc

Warm Air Furnace,
Oil Fired
(outdoor installation)

<225,000 Btu/h

DOE 10 CFR Part 430
or UL 727

78% AFUE or
80% Etd,f

>225,000 Btu/h

Maximum Capacitye

UL 727

81% Etf

Warm Air Furnace,
Oil Fired
(indoor installation)

<225,000 Btu/h

DOE 10 CFR Part 430
or UL 727

90% AFUE or
92% Etd,f

>225,000 Btu/h

Maximum Capacitye

UL 727

92% Etf

Warm Air duct Furnaces,
Gas-Fired
(outdoor installation)

All Capacities

Maximum Capacitye

ANSI Z83.9

80% Ecg

Warm Air duct Furnaces,
Gas-Fired
(indoor installation)

All Capacities

Maximum Capacitye

ANSI Z83.9

90% Ecg

Warm Air Unit Heaters, Gas
Fired
(indoor installation)

All Capacities

Maximum Capacitye

ANSI Z83.8

90% Ecg,h

Warm Air Unit Heaters, Oil
Fired
(indoor installation)

All Capacities

Maximum Capacitye

UL 731

90% Ecg,h

a Et = thermal efficiency. See test procedure for detailed discussions

b Section 12 contains a complete specification of the referenced test procedure, including the referenced year version
of the test procedure

c Ec = combustion efficiency. Units shall also include an interrupted or intermittent ignition device (IID), have jacket
losses not exceeding 0.75% of the input rating, and have either power venting or flue damper. A vent damper is an
acceptable alternative to the flue damper for those furnaces where combustion air is drawn from the conditioned
space.

d Combustion units not covered by NAECA (3-phase power or cooling capacity greater than or equal to 65,000 Btu/h)
is allowed to comply with either rating

e Minimum and maximum ratings as provided for and allowed by the unit's controls

f Et = combustion efficiency. Units shall also include an interrupted or intermittent ignition device (IID), have jacket

losses not exceeding 0.75% of the input rating, and have either power venting or flue damper. A vent damper is an
acceptable alternative to the flue damper for those furnaces where combustion air is drawn from the conditioned
space.

g Ec = combustion efficiency (100% less flue losses) See test procedures for detailed discussion

h As of August 8, 2008, according to the Energy Policy Act of 2005, units shall also include an interrupted or
intermittent ignition devices (IID) and have either power venting or automatic flue dampers. A vent damper is an
acceptable alternative to a flue damper for those unit heaters where combustion air is drawn from the conditioned
space.

Table C-14 (supersedes Table 6.8.1F in ASHRAE/IESNA Standard 90.1)

Gas and Oil Fired Boilers - Minimum Efficiency Requirements (I-P)

Equipment Type

Subcategory
or
Rating
Condition

Size Category
(Input)

Efficiency

Test Procedure

Boilers, hot water

Gas Fired

<300,000 Btu/h

89 % AFUE

10 CFR Part
430

>300,000 Btu/h and
<2,500,000 Btu/hd

89% Et

10 CFR Part
431

>2,500,000 Btu/ha

91% Ec

Oil Firede

<300,000 Btu/h

89 % AFUE

10 CFR Part
430

>300,000 Btu/h and
<2,500,000 Btu/hd

89% Et

10 CFR Part
431

>2,500,000 Btu/ha

91% Ec

Boilers, steam

Gas Fired

<300,000 Btu/h

75% AFUE

10 CFR Part
430

Gas fired
all, except
natural draft

>300,000 Btu/h and
<2,500,000 Btu/hd

79% Et

10 CFR Part
431

>2,500,000 Btu/ha

79% Et

Gas-fired
natural draft

>300,000 Btu/h and
<2,500,000 Btu/hd

77% Et

>2,500,000 Btu/ha

77% Et

Oil Firede

<300,000 Btu/h

80% Et

10 CFR Part
430

>300,000 Btu/h and
<2,5000,000 Btu/hd

81% Et

10 CFR Part
431

>2,500,000 Btu/ha

81% Et

a These requirements apply to boilers with rated input of 8,000,000 Btu/h or less that are not packaged
boilers, and to all packaged boilers. Minimum efficiency requirements for boilers cover all
capacities of packaged boilers.

b Ec = thermal efficiency (100% less flue losses). See reference document for detailed information.

c Et = thermal efficiency. See reference document for detailed information.

d Maximum capacity - minimum and maximum ratings as provided for and allowed by the unit's
controls

e Includes oil fired (residual)

f Systems shall be designed with lower operating return hot water temperatures (<130°F) and use hot
water reset to take advantage of the much higher efficiencies of condensing boilers

Table C-15 (supersedes Table 6.8.1G in ASHRAE/IESNA Standard 90.1)

Performance Requirements for Heat Rejection Equipment (I-P)

Equipment Type

Total System
Heat Rejection
Capacity at
Rated
Conditions

Rating Standard

Rating Conditions
(Annual Cooling Design,
ASHRAE Standard 169,
Table A1, Column 10c)

Performance
Requireda,b

Full Load
Maximum
Approach c

Open loop
Propeller or Axial
Fan Cooling
Towers

All

CTI ATC-105
and CTI STD-
201

1.0% Design
Evaporation WB
temperature

>40 gpm/hp

6°F above 1.0%
Design
Evaporation WB
temperature

Closed Loop
Propeller or Axial
Fan Cooling
Towers

All

CTI ATC-105

and CTI STD-
201

1.0% Design
Evaporation WB
temperature

>15 gpm/hp

8°F above 1.0%
Design
Evaporation WB
temperature

Open Loop
Centrifugal Fan
Cooling Towers

All

CTI ATC-105
and CTI STD-
201

1.0% Design
Evaporation WB
temperature

>22.0
gpm/hp

6°F above 1.0%

Design
Evaporation WB
temperature

Closed Loop
Centrifugal Fan
Cooling Towers

All

CTI ATC-105

and CTI STD-
201

1.0% Design
Evaporation WB
temperature

>8 gpm/hp

8°F above 1.0%
Design
Evaporation WB
temperature

Air-Cooled
Condensers

All

ARI 460

not applicable, air cooled
condenser shall be matched to the
HVAC system and rated per tables
C3

A For purposes of this table, cooling tower performance is defined as the maximum flow rating of the tower divided
by the fan nameplate rated motor power.

B For purposes of this table, air-cooled condenser performance is defined as the heat rejected from the refrigerant
divided by the fan nameplate rated motor power.

C The approach is the design tower leaving water temperature - the building 1.0% annual cooling design
Evaporation WB temperature from ASHRAE Standard 169, Table A1, Column 10c.

Table C-16 (supersedes Table 6.8.2A in ASHRAE/IESNA Standard 90.1)

Minimum Duct Insulation R-Valuea

Cooling and Heating Only Supply Ducts and Return Ducts (I-P)

Climate Zone

Duct Location

Exterior

Ventilated
Attic

Unvented Attic
Above Insulated
Ceiling

Unvented Attic
with Roof
Insulationa

Unconditioned
Spaceb

Indirectly
Conditioned
Spacec

Buried

Heating Ducts
Only

Heating Ducts Only

1, 2

none

none

none

none

none

none

none

3

R-6

none

none

none

R-6

none

none

4

R.6

none

none

none

R-6

none

none

5

R-8

R-6

none

none

R-6

none

R-6

6

R-8

R-8

R-6

none

R-6

none

R-6

7

R-10

R-8

R-8

none

R-6

none

R-6

8

R-10

R-10

R-8

none

R-8

none

R-8

Cooling Only
Ducts

Cooling Only Ducts

1

R-6

R-8

R-10

R-6

R-6

none

R-6

2

R-6

R-8

R-10

R-6

R-6

none

R-6

3

R-6

R-8

R-8

R-6

R-3.5

none

none

4

R-3.5

R-6

R-8

R-3.5

R-3.5

none

none

5, 6

R-3.5

R-3.5

R-6

R-3.5

R-3.5

none

none

7, 8

R-1.9

R-3.5

R-3.5

R-3.5

R-3.5

none

none

Return Ducts

Return Ducts

1 to 8

R-6

R-6

R-6

none

none

none

none

a Insulation R-values, measured in (h·ft2·°F)/Btu, are for the insulation as installed and do not include film
resistance. The required minimum thicknesses do not consider water vapor transmission and possible surface
condensation. Where exterior walls are used as plenum walls, wall insulation shall be as required by the most
restrictive condition of 6.4.4.2 or Section 5. Insulation resistance measured on a horizontal plane in accordance
with ASTM C518 at a mean temperature of 75°F at the installed thickness.

b Includes crawl spaces, both ventilated and nonventilated.

c Includes return air plenums with or without exposed roofs above.

Table C-17 (supersedes Table 6.8.2B in ASHRAE/IESNA Standard 90.1)

Minimum Duct Insulation R-Valuea,

Combined Heating and Cooling Supply Ducts and Return Ducts (I-P)

Climate Zone

Duct Location

Exterior

Ventilated

Attic

Unvented Attic Above
Insulated Ceiling

Unvented

Attic w/ Roof

Insulationa

Unconditioned
Spaceb

Indirectly
Conditioned
Spacec

Buried

Supply Ducts

1

R-8

R-8

R-10

R-6

R-6

none

R-6

2

R-8

R-8

R-8

R-6

R-8

none

R-6

3

R-8

R-8

R-8

R-6

R-8

none

R-6

4

R-8

R-8

R-8

R-6

R-8

none

R-6

5

R-8

R-8

R-8

R-3.5

R-8

none

R-6

6

R-10

R-8

R-8

R-3.5

R-8

none

R-6

7

R-10

R-8

R-8

R-3.5

R-8

none

R-6

8

R-10

R11

R11

R-3.5

R-8

none

R-8

Return Ducts

1 to 8

R-6

R-6

R-6

none

none

none

none

a Insulation R-values, measured in (h·ft2·°F)/Btu, are for the insulation as installed and do not include film resistance. The required minimum thicknesses do not consider water vapor transmission and possible surface condensation. Where exterior walls are used as plenum walls, wall insulation shall be as required by the most restrictive condition of 6.4.4.2 or Section 5. Insulation resistance measured on a horizontal plane in accordance with ASTM C518 at a mean temperature of 75°F at the installed thickness.

b Includes crawl spaces, both ventilated and non-ventilated.

c Includes return air plenums with or without exposed roofs above.

Table C-18 (supersedes Table 6.8.3 in ASHRAE/IESNA Standard 90.1)

Minimum Pipe Insulation Thicknessa (I-P)

Fluid Design
Operating Temp.
Range (°F)

Insulation Conductivity

Nominal Pipe or Tube Size (in.)

Conductivity
Btu·in./(h·ft2·°F)

Mean
Rating
Temp. °F

<1

1 to <1-1/2

1-1/2 to <4

4 to <8

>8

Heating Systems (Steam, Steam Condensate, and Hot Water)b,c

>350

0.32-0.34

250

3.0

3.5

3.5

4.5

4.5

251-350

0.29-0.32

200

2.0

3.0

3.5

3.5

3.5

201-250

0.27-0.30

150

2.0

2.0

2.5

2.5

2.5

141-200

0.25-0.29

125

1.5

1.5

1.5

2.0

2.0

105-140

0.22-0.28

100

1.0

1.0

1.5

1.5

1.5

Domestic and Service Hot Water Systems

105+

0.22-0.28

100

1.0

1.0

1.5

1.5

1.5

Cooling Systems (Chilled Water, Brine, and Refrigerant)[d]

40-60

0.22-0.28

100

1.0

1.0

1.5

1.5

1.5

<40

0.22-0.28

100

1.0

1.5

1.5

1.5

2.0

a For insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows:

$$T = r\{(1 + t/r)K/k - 1\}$$

where T = minimum insulation thickness (in.), r = actual outside radius of pipe (in.), t = insulation thickness listed
in this table for applicable fluid temperature and pipe size, K = conductivity of alternate material at mean rating
temperature indicated for the applicable fluid temperature (Btu·in.[h·ft2·°F]); and k= the upper value of the
conductivity range listed in this table for the applicable fluid temperature.

b These thicknesses are based on energy efficiency considerations only. Additional insulation is sometimes required
relative to safety issues/surface temperature.

c Piping insulation is not required between the control valve and coil on run-outs when the control valve is located
within 4 ft of the coil and the pipe size is 1 in. or less.

d These thicknesses are based on energy efficiency considerations only. Issues such as water vapor permeability or
surface condensation sometimes require vapor retarders or additional insulation.

Table C-19 (supersedes Table 7.8 in ASHRAE/IESNA Standard 90.1)

Performance Requirements for Water Heating Equipment (I-P)

Equipment Type

Size Category
(Input)

Subcategory or
Rating Condition

Performance Required a

Test
Procedure b

Electric Water
Heaters

12 kW

Resistance > 20 gal

0.93-0.00132V EF

DOE 10 CFR
Part 430

>12 kW

Resistance > 20 gal

20 + 35 V.5 SL, Btu/h

ANSI Z21.10.3

24 Amps and
< 250 volts

Heat Pump

0.93-0.00132V EF

DOE 10 CFR
Part 430

Gas Storage Water
Heaters

<75,000 Btu/h

>20 gal

0.62-0.0019V EF

DOE 10 CFR
Part 430

>75,000 Btu/h

<4000 (Btu/h)/gal

80% Et (Q/800 + 110 V.5) SL, Btu/h

ANSI Z21.10.3

Gas Instantaneous
Water Heaters

>50,000 Btu/h and
<200,000 Btu/h

> 4000 (Btu/h)/gal
and < 2 gal

0.62-0.0019V EF

DOE 10 CFR
Part 430

> 200,000 Btu/hc

> 4000 (Btu/h)/gal
and < 10 gal

80% Et

ANSI Z21.10.3

>200,000 Btu/h

4000 (Btu/h)/gal
and > 10 gal

80% Et (Q/800 + 110 V.5) SL, Btu/h

Oil Storage Water
Heaters

<105,000 Btu/h

> 20 gal

0.59-0.0019V EF

DOE 10 CFR
Part 430

>105,000 Btu/h

<4000 (Btu/h)/gal

78% Et (Q/800 + 110 V.5) SL, Btu/h

ANSI Z21.10.3

Oil Instantaneous Water
Heaters

< 210,000 Btu/h

> 4000 (Btu/h)/gal
and < 2 gal

0.59-0.0019V EF

DOE 10 CFR
Part 430

>210,000 Btu/h

> 4000 (Btu/h)/gal
and < 10 gal

80% Et

ANSI Z21.10.3

>210,000 Btu/h

> 4000 (Btu/h)/gal
and > 10 gal

78% Et (Q/800 + 110 V.5) SL, Btu/h

Hot Water Supply
Boilers, Gas and Oil

300,000 Btu/h and
<12,500,000 Btu/h

> 4000 (Btu/h)/gal
and < 10 gal

80% Et

ANSI Z21.10.3

Hot Water Supply
Boilers, Gas

> 4000 (Btu/h)/gal
and > 10 gal

80% Et (Q/800 + 110 V.5) SL, Btu/h

Hot Water Supply
Boilers, Oil

> 4000 (Btu/h)/gal
and > 10 gal

78% Et (Q/800 + 110 V.5) SL, Btu/h

Pool Heaters
Oil and Gas

All

78% Et

ASHRAE 146

Heat Pump Pool Heaters

All

4.0 COP

ASHRAE 146

Unfired Storage
Tanks

All

R-12.5

(none)

a Energy factor (EF) and thermal efficiency (Et) are minimum requirements, while standby loss (SL) is maximum
Btu/h based on a 70°F temperature difference between stored water and ambient requirements. In the EF
equation, V is the rated volume in gallons. In the SL equation, V is the rated volume in gallons and Q is the
nameplate input rate in Btu/h.

b Section 12 contains a complete specification, including the year version, of the referenced test procedure.

c Instantaneous water heaters with input rates below 200,000 Btu/h shall comply with these requirements if the
water heater is designed to heat water to temperatures 180°F or higher."

TABLE C-20 Minimum Nominal Efficiency

for General Purpose Design A and Design B Motorsa (I-P)

Minimum Nominal Full-Load Efficiency (%)

Open Motors

Enclosed Motors

Number of Poles ==>

2

4

6

2

4

6

Synchronous Speed (RPM)
==>

3600

1800

1200

3600

1800

1200

Motor Horsepower

1

77.0

85.5

82.5

77.0

85.5

82.5

1.5

84.0

86.5

86.5

84.0

86.5

87.5

2

85.5

86.5

87.5

85.5

86.5

88.5

3

85.5

89.5

88.5

86.5

89.5

89.5

5

86.5

89.5

89.5

88.5

89.5

89.5

7.5

88.5

91.0

90.2

89.5

91.7

91.0

10

89.5

91.7

91.7

90.2

91.7

91.0

15

90.2

93.0

91.7

91.0

92.4

91.7

20

91.0

93.0

92.4

91.0

93.0

91.7

25

91.7

93.6

93.0

91.7

93.6

93.0

30

91.7

94.1

93.6

91.7

93.6

93.0

40

92.4

94.1

94.1

92.4

94.1

94.1

50

93.0

94.5

94.1

93.0

94.5

94.1

60

93.6

95.0

94.5

93.6

95.0

94.5

75

93.6

95.0

94.5

93.6

95.4

94.5

100

93.6

95.4

95.0

94.1

95.4

95.0

125

94.1

95.4

95.0

95.0

95.4

95.0

150

94.1

95.8

95.4

95.0

95.8

95.8

200

95.0

95.8

95.4

95.4

96.2

95.8

250

95.0

95.8

95.4

95.8

96.2

95.8

300

95.4

95.8

95.4

95.8

96.2

95.8

350

95.4

95.8

95.4

95.8

96.2

95.8

400

95.8

95.8

95.8

95.8

96.2

95.8

450

95.8

96.2

96.2

95.8

96.2

95.8

500

95.8

96.2

96.2

95.8

96.2

95.8

a Nominal efficiencies shall be established in accordance with NEMA Standard MG1. Design A and Design B are National Electric Manufacturers Association (NEMA) design class designations for fixed frequency small and medium AC squirrel-cage induction motors.

Table C-21 – Transformer Minimum Efficiencies (I-P)

Rated Capacity
(kVA)

600 Volts or less a

Single Phase

10

--

15

97.7

25

98.0

37.5

98.2

50

98.3

75

98.5

100

98.6

167

98.7

250

98.8

333

98.9

3 Phase

15

97.0

30

97.5

45

97.7

75

98.0

112.5

98.2

150

98.3

225

98.5

300

98.6

500

98.7

750

98.8

1000

98.9

a Ratings are based on the DOE Test Procedure defined in Part 431 section 323(b)(10) and 346(a) at a rating
temperature of 167°F and a load of 35% of the nameplate load

Table C-22 Commercial Refrigerator & Freezers (I-P)

Equipment Type

Application

Energy Use Limit
(kW/h per day)

Refrigerators with solid doors

holding temperature

0.10 V + 2.04

Refrigerators with transparent doors

0.12 V + 3.34

Freezers with solid doors

0.40 V + 1.38

Freezers with transparent doors

0.75 V + 4.10

Refrigerators/freezers with solid
doors

the greater of 0.12 V + 3.34 or
0.70

Commercial Refrigerators

pulldown

0.126 V + 3.51

V means the chiller or frozen compartment volume (ft^3) as defined in the Association of Home
Appliance manufacturers Standard HRF1-1979

Table C-23 Commercial Clothes Washers (I-P)

Product	MER	WF
All Commercial Clothes Washers	1.72	8

MER = Modified Energy Factor, a combination of Energy Factor and MEF=Modified Energy Factor, a combination of Energy Factor and Remaining Moisture Content. MEF measures energy consumption of the total laundry cycle (washing and drying). It indicates how many cubic feet of laundry can be washed and dried with one kWh of electricity; the higher the number, the greater the efficiency.

(This is a normative appendix and is part of this standard.)

NORMATIVE APPENDIX D

PERFORMANCE OPTION FOR ENERGY EFFICIENCY

D1 General

D1.1 Performance Option Scope. This building performance option is a modification of the Energy Cost Budget (ECB) Method in Section 11 of ASHRAE/IESNA Standard 90.1 and Appendix G of ASHRAE/IESNA Standard 90.1. This appendix offers an alternative to 7.4 for compliance with ASHRAE/USGBC/IESNA Standard 189.1. Also, it is provided for those wishing to use the methodology developed for this standard to quantify performance that substantially exceeds the requirements of ASHRAE/USGBC/IESNA Standard 189.1. It may be useful for evaluating the performance of all proposed designs, including alterations and additions to existing buildings, except designs with no mechanical systems.

D1.2 Performance Option. This performance option requires conformance with the following provisions:

(a) All requirements of Sections 5.4, 6.4, 7.4, 8.4, 9.4, and 10.4 of ASHRAE/IESNA Standard 90.1 and 7.3 are complied with. These sections contain the mandatory provisions of the standard, and are prerequisites.

(b) The proposed design shall only vary from requirements in 7.4 where those variations have been accurately and completely modeled. Where variations are not specifically analyzed (e.g. the requirements in 7.4.3(n) for pipe insulation), the proposed design shall comply with those requirements.

(c) The improved performance of the proposed building design is calculated in accordance with provisions of this appendix using the following formula:

Percentage improvement = 100 × (Baseline building performance - Proposed building performance) / Baseline building performance

Notes:

1. Both the proposed building performance and the baseline building performance shall include all end-use load components, such as receptacle and process loads.

2. Neither the proposed building performance nor the baseline building performance are predictions of actual energy consumption or costs for the proposed design after construction. Actual experience will differ from these calculations due to variations such as occupancy, building operation and maintenance, weather, energy use not covered by this procedure, changes in energy rates between design of the building and occupancy, and the precision of the calculation tool.

D1.3 Trade-Off Limits. When the proposed modifications apply to less than the whole building, only parameters related to the systems to be modified shall be allowed to vary. Parameters relating to unmodified existing conditions or to future building components shall be identical for determining both the baseline building performance and the proposed building performance. Future building components shall comply with the prescriptive requirements of Sections 5.5, 6.5, 7.5, 9.5, and 9.6 of ASHRAE/IESNA Standard 90.1 and 7.4.

D1.4 Documentation Requirements. Simulated performance shall be documented, and documentation shall be submitted to the authority having jurisdiction. The information submitted shall include the following:

(a) Calculated values for the baseline building performance, the proposed building performance, and the percentage improvement.

(b) A list of the energy-related features that are included in the design and on which the performance is based. This list shall document all energy features that differ between the models used in the baseline building performance and proposed building performance calculations.

(c) Input and output report(s) from the simulation program or compliance software including a breakdown of energy usage by at least the following components: interior lighting, façade lighting, parking lighting, space heating, space cooling, interior fans, parking garage fans, pumps, service water heating, office equipment, elevators and escalators, refrigeration, commercial cooking; and energy production by on-site renewable energy power systems. The output reports shall also show the amount of time any loads are not met by the HVAC system for both the proposed design and baseline building design.

(d) An explanation of any error messages noted in the simulation program output.

D2 Simulation General Requirements

D2.1 Performance Calculations. The proposed building performance and baseline building performance shall be calculated using the following:

(a) the same simulation program,

(b) the same weather data, and

(c) the same energy rates.

D2.2 Simulation Program. The simulation program shall be a computer-based program for the analysis of energy consumption in buildings. The simulation program shall include calculation methodologies for the building components being modeled. For components that cannot be modeled by the simulation program, the exceptional calculation methods requirements in Section D2.5 may be used.

D2.2.1 The simulation program shall be approved by the authority having jurisdiction and shall, at a minimum, have the ability to explicitly model all of the following:

(a) 8,760 hours per year;

(b) hourly variations in occupancy, lighting power, miscellaneous equipment power, thermostat setpoints, and HVAC system operation, defined separately for each day of the week and holidays;

(c) thermal mass effects;

(d) ten or more thermal zones;

(e) part-load performance curves for mechanical equipment;

(f) capacity and efficiency correction curves for mechanical heating and cooling equipment;

(g) air-side economizers with integrated control;

(h) on-site renewable energy power systems;

(i) baseline building design characteristics specified in D3.

D2.2.2 The simulation program shall have the ability to either: directly determine the proposed building performance and baseline building performance, or produce hourly reports of energy use by an energy source suitable for determining the proposed building performance and baseline building performance using a separate calculation engine.

D2.2.3 The simulation program shall be capable of performing design load calculations to determine required HVAC equipment capacities and air and water flow rates in accordance with generally accepted engineering standards and handbooks for both the proposed design and baseline building design.

D2.2.4 The simulation program shall be tested according to ASHRAE Standard 140, and the results shall be furnished by the software provider.

D2.3 Climate Data. The simulation program shall perform the simulation using hourly values of climate data, such as temperature and humidity from representative climate data, for the site in which the proposed design is to be located. For cities or urban regions with several climate data entries, and for locations where weather data are not available, the designer shall select available weather data that best represent the climate at the construction site. The selected weather data shall be approved by the authority having jurisdiction.

D2.4 Energy Rates. Annual energy costs shall be determined using either actual rates for purchased energy or state average energy prices published by USDOE's Energy Information Administration (EIA) for commercial building customers, but rates from different sources may not be mixed in the same project.

(Informative Note: The above provision allows users to gain credit for features that yield load management benefits. Where such features are not present, users can simply use state average unit prices from EIA.)

Exception to D2.4: On-site renewable energy sources or site-recovered energy shall not be considered to be purchased energy and shall not be assigned an energy cost in the baseline building performance or in the proposed building performance. Where on-site renewable or site-recovered sources are used as the primary energy source in the proposed building, the portion of the baseline building performance that is not provided by an on-site renewable energy power system shall be based on the energy source used as the backup energy source or on the use of electricity if no backup energy source has been specified.

D2.5 Exceptional Calculation Methods. Where no simulation program is available that adequately models a design, material, or device, the authority having jurisdiction may approve an exceptional calculation method to demonstrate above-standard performance using this method. Applications for approval of an exceptional method shall include documentation of the calculations performed and theoretical and/or empirical information supporting the accuracy of the method.

D3 Calculation of the Proposed and Baseline Building Performance

D3.1 Building Performance Calculations. The simulation model for calculating the proposed and baseline building performance shall be developed in accordance with the requirements in Table D3.1 and shall not be less stringent than the requirements in 7.3 and 7.4.

D3.1.1 Baseline HVAC System Type and Description. HVAC systems in the baseline building design shall be based on usage, number of floors, conditioned floor area, and heating source as specified in Table D3.1.1A and shall conform with the system descriptions in Table D3.1.1B. For systems 1, 2, 3, and 4, each thermal block shall be modeled with its own HVAC system. For systems 5, 6, 7, and 8, each floor shall be modeled with a separate HVAC system. Floors with identical thermal blocks can be grouped for modeling purposes.

Exceptions to D3.1.1:

(a) Use additional system type(s) for non-predominant conditions (i.e., residential/nonresidential or heating source) if those conditions apply to more than 2,000 m2 (20,000 ft2) of conditioned floor area.

(b) If the baseline HVAC system type is 5, 6, 7, or 8, use separate single-zone systems conforming with the requirements of System 3 or System 4 (depending on building heating source) for any spaces that have occupancy or process loads or schedules that differ significantly from the rest of the building. Peak thermal loads that differ by 30 W/m2 (10 Btu/h-ft2) or more from the average of other spaces served by the system or schedules that differ by more than 40 equivalent full-load hours per week from other spaces served by the system are considered to differ significantly. Examples where this exception may be applicable include, but are not limited to, computer server rooms, natatoriums, and continually-occupied security areas.

(c) If the baseline HVAC system type is 5, 6, 7, or 8, use separate single-zone systems conforming with the requirements of System 3 or System 4 (depending on building heat source) for any zones having special pressurization relationships, cross-contamination requirements, or code-required minimum circulation rates.

(d) For laboratory spaces with a minimum of 2,500 L/s (5,000 cfm) of exhaust, use system type 5 or 7 that reduce the exhaust and makeup air volume to 50% of design values during unoccupied periods. For all-electric buildings, the heating shall be electric resistance.

D3.1.1.1 Purchased Heat. For systems using purchased hot water or steam, hot water or steam costs shall be based on actual utility rates, and on-site boilers shall not be modeled in the baseline building design.

D3.1.2 General Baseline HVAC System Requirements. HVAC systems in the baseline building design shall conform with the general provisions in this section.

D3.1.2.1 Equipment Efficiencies. All HVAC equipment in the baseline building design shall be modeled at the minimum efficiency levels, both part load and full load, in accordance with 7.4.3(b). Where efficiency ratings, such as EER and COP, include fan energy, the descriptor shall be broken down into its components so that supply fan energy can be modeled separately.

TABLE D3.1 Modeling Requirements for Calculating Proposed and Baseline Building Performance

No.

Proposed Building Performance

Baseline Building Performance

1.

Design Model

(a) The simulation model of the proposed design shall be consistent with the design documents, including proper accounting of fenestration and opaque envelope types and areas; interior lighting power and controls; HVAC system types, sizes, and controls; and service water heating systems and controls. All end-use load components within and associated with the building shall be modeled, including, but not limited to, exhaust fans, parking garage ventilation fans, snow-melt and freeze-protection equipment, facade lighting, swimming pool heaters and pumps, elevators and escalators, refrigeration, and cooking. Where the simulation program does not specifically model the functionality of the installed system, spreadsheets or other documentation of the assumptions shall be used to generate the power demand and operating schedule of the systems.

The baseline building design shall be modeled with the same number of floors and identical conditioned floor area as the proposed design.

(b) All conditioned spaces in the proposed design shall be simulated as being both heated and cooled even if no heating or cooling system is to be installed, and temperature and humidity control set-points and schedules shall be the same for proposed and baseline building designs.

(c) When the performance option is applied to buildings in which energy-related features have not yet been designed (e.g., a lighting system), those yet-to-be-designed features shall be described in the proposed design exactly as they are defined in the baseline building design. Where the space classification for a space is not known, the space shall be categorized as an office space.

TABLE D3.1 (Continued) Modeling Requirements for Calculating Proposed and

Baseline Building Performance

No.

Proposed Building Performance

Baseline Building Performance

2.

Additions and Alterations

It is acceptable to predict performance using building models that exclude parts of the existing building provided that all of the following conditions are met:

(a) Work to be performed in excluded parts of the building shall comply with the requirements of 7.3 and 7.4.

(b) Excluded parts of the building are served by HVAC systems that are entirely separate from those serving parts of the building that are included in the building model.

(c) Design space temperature and HVAC system operating set-points and schedules on either side of the boundary between included and excluded parts of the building are essentially the same.

(d) If a declining block or similar utility rate is being used in the analysis and the excluded and included parts of the building are on the same utility meter, the rate shall reflect the utility block or rate for the building plus the addition.

Same as Proposed Design

3.

Space Use Classification

Usage shall be specified using the building type or space type lighting classifications in accordance with Section 9.5.1 or 9.6.1 of ASHRAE/IESNA Standard 90.1. The user shall specify the space use classifications using either the building type or space type categories but shall not combine the two types of categories. More than one building type category may be used in a building if it is a mixed-use facility. If space type categories are used, the user may simplify the placement of the various space types within the building model, provided that building-total areas for each space type are accurate.

Same as Proposed Design

4.

Schedules

Schedules capable of modeling hourly variations in occupancy, lighting power, miscellaneous equipment power, thermostat setpoints, and HVAC system operation shall be used. The schedules shall be typical of the proposed building type as determined by the designer and approved by the authority having jurisdiction.

HVAC Fan Schedules. Schedules for HVAC fans shall run continuously whenever spaces are occupied and shall be cycled on and off to meet heating and cooling loads during unoccupied hours.

Exceptions:

(a) Where no heating and/or cooling system is to be installed and a heating or cooling system is being simulated only to comply with the requirements described in this table, heating and/or cooling system fans shall not be simulated as running continuously during occupied hours but shall be cycled on and off to meet heating and cooling loads during all hours.

(b) HVAC fans shall remain on during occupied and unoccupied hours in spaces that have health and safety mandated minimum ventilation requirements during unoccupied hours.

Same as Proposed Design.

Exception: Schedules may be allowed to differ between proposed design and baseline building design when necessary to model nonstandard efficiency measures for those cases where the measures exceed the requirements in this standard, provided that the revised schedules have the approval of the authority having jurisdiction. Measures that may warrant use of different schedules include, but are not limited to, lighting controls in addition to those required by 7.4.6, natural ventilation in addition to the outdoor air quantities required by 8.3.1, demand control ventilation in addition to that required by 7.4.3, and measures that reduce service water heating loads in addition to that required by 6.3.2, 6.4.2, 7.4.4, and 7.4.7.

TABLE D3.1 (Continued) Modeling Requirements for Calculating Proposed and

Baseline Building Performance

5.

Building Envelope

All components of the building envelope in the proposed design shall be modeled as shown on architectural drawings or as built for existing building envelopes.

Exceptions: The following building elements are permitted to differ from architectural drawings.

(a) All uninsulated assemblies (e.g., projecting balconies, perimeter edges of intermediate floor stabs, concrete floor beams over parking garages) shall be separately modeled using either of the following techniques:

1. Separate model of each of these assemblies within the energy simulation model.

2. Separate calculation of the U-factor for each of these assemblies. The U-factors of these assemblies are then averaged with larger adjacent surfaces using an area-weighted average method. This average U-factor is modeled

within the energy simulation model.

Any other envelope assembly that covers less than 5% of the total area of that assembly type (e.g., exterior walls) need not be separately described provided that it is similar to an assembly being modeled. If not separately described, the area of an envelope assembly shall be added to the area of an assembly of that same type with the same orientation and thermal properties.
(b) Exterior surfaces whose azimuth orientation and tilt differ by less than 45 degrees and are otherwise the same may be described as either a single surface or by using multipliers.

(c) For exterior roofs, the roof surface may be modeled with a reflectance of 0.45 if the reflectance of the proposed design roof is greater than 0.70 and its emittance is greater than 0.75. Reflectance values shall be based on testing in accordance with ASTM C1549, or ASTM E1918, and emittance values shall be based on testing in accordance with ASTM C1371 or ASTM E408, and SRI shall be based on ASTM E1980 calculated at medium wind speed. All other roof surfaces shall be modeled with a reflectance of 0.30.

(d) Manual fenestration shading devices such as blinds or shades shall not be modeled. Automatically controlled fenestration shades or blinds may be modeled. Permanent shading devices such as fins, overhangs, and light shelves may be modeled.

Equivalent dimensions shall be assumed for each exterior envelope component type as in the proposed design; i.e., the total gross area of exterior walls shall be the same in the proposed and baseline building designs. The same shall be true for the areas of roofs, floors, and doors, and the exposed perimeters of concrete slabs on grade shall also be the same in the proposed and baseline building designs. The following additional requirements shall apply to the modeling of the baseline building design:

(a) Orientation. The baseline building performance shall be generated by simulating the building with its actual orientation and again after rotating the entire building 90, 180, 270 degrees, then averaging the results. The building shall be modeled so that it does not shade itself.

(b) Opaque assemblies. Opaque assemblies used for new buildings or additions shall conform with the following common, lightweight assembly types and shall match the appropriate assembly maximum U-factors in Tables A-1 through A-8:

• Roofs – Insulation entirely above deck

• Above-grade walls– Steel-framed

• Floors – Steel-joist

• Opaque door types shall match the proposed design and conform to the U-factor requirements from the same tables.

• Slab-on-grade floors shall match the F-factor for unheated slabs from the same tables. Opaque assemblies used for alterations shall conform with Section 5.1.3 of ASHRAE/IESNA Standard 90.1 as modified by 7.3 and 7.4.

(c) Vertical Fenestration. Vertical fenestration areas for new buildings and additions shall equal that in the proposed design or 40% of gross above-grade wall area, whichever is smaller, and shall be distributed uniformly in horizontal bands across the four orientations. Fenestration U-factors shall match the appropriate requirements in Tables A-1 through A-8 for the applicable vertical fenestration framing system type. Fenestration solar heat gain coefficient (SHGC) shall match the appropriate requirements in Tables A-1 through A-8 using the value for

SHGCall provided that the vertical fenestration in the proposed building complies with 7.4.2(i). If not, then the SHGC for west-facing and east-facing fenestration in the baseline building shall be uniformly reduced until the vertical fenestration in the baseline building complies with 7.4.2(i). Using the vertical fenestration area specified above, the vertical fenestration visible light transmittance shall be determined so that the vertical fenestration complies with the effective aperture requirements in 8.4.1. All vertical fenestration shall be modeled as fixed and shall be assumed to be flush with the exterior wall, and with shading by a permanent projection complying with 7.4.2(e). Manual window shading devices such as blinds or shades shall not be modeled. The fenestration areas for envelope alterations shall reflect the limitations on area, U-factor, and SHGC as described in Section 5.1.3 of ASHRAE/IESNA Standard 90.1 as modified by 7.3 and 7.4.

(d) Skylights and Glazed Smoke Vents. Skylight area shall be equal to that in the proposed building design or 5% of the gross roof area that is part of the building envelope, whichever is smaller, but not less than that required in 8.3.7. If the skylight area of the proposed building design is greater than 5% of the gross roof area, baseline skylight area shall be decreased by an identical percentage in all roof components in which skylights are located to reach the 5% skylight-to-roof ratio. Skylight orientation and tilt shall be the same as in the proposed building design. Skylight U-factor and SHGC properties shall match the appropriate requirements in Tables A-1 through A-8 and shall comply with the requirements in 8.3.7(b).

(e) Roof albedo. Those roof surfaces subject to 5.3.2.3 shall be modeled with a reflectivity of 0.45. All other roof surfaces shall be modeled with a reflectivity of 0.30.

(f) Existing Buildings. For existing building envelopes, the baseline building design shall reflect existing conditions prior to any revisions that are part of the scope of work being evaluated.

TABLE D3.1 (Continued) Modeling Requirements for Calculating Proposed and

Baseline Building Performance

No.

Proposed Building Performance

Baseline Building Performance

6.

Lighting

Lighting power in the proposed design shall be determined as follows:

(a) Where a complete lighting system exists, the actual lighting power shall be used in the model.

(b) Where a lighting system has been designed, lighting power shall be determined in accordance with Sections 9.1.3 and 9.1.4 of ASHRAE/IESNA Standard 90.1.

(c) Where lighting neither exists nor is specified, lighting power shall be determined in accordance with the Building Area Method for the appropriate building type.

(d) Lighting system power shall include all lighting system components shown or provided for on the plans (including lamps and ballasts and task and furniture-mounted fixtures).

Exception: For multifamily living units, hotel/motel guest rooms, and other spaces in which lighting systems are connected via receptacles and are not shown or provided for on building plans, assume identical lighting power for the proposed and baseline building designs in the simulations.

(e) Lighting power for parking garages and building facades shall be modeled.

(f) Credit may be taken for the use of automatic controls for daylight utilization in excess of that required by 7.4.6, 8.3.7, and 8.4.1 but only if their operation is either modeled directly in the building simulation or modeled in the building simulation through schedule adjustments determined by a separate daylighting analysis approved by the authority having jurisdiction.

(g) For automatic lighting controls in addition to those required for minimum code compliance under Section 9.4.1 of ASHRAE/IESNA Standard 90.1 and 7.4.6, 8.3.7, and 8.4.1, credit may be taken for automatically controlled systems by reducing the connected lighting power by the applicable percentages listed in Table D3.2. Alternatively, credit may be taken for these devices by modifying the lighting schedules used for the proposed design, provided that credible technical documentation for the modifications are provided to the authority having jurisdiction.

Lighting power in the baseline building design shall be determined using the same categorization procedure (building area or space function) and categories as the proposed design with lighting power set equal to the maximum allowed for the corresponding method and category in Section 9.2 of ASHRAE/IESNA Standard 90.1 and 7.4.6. Automatic lighting controls shall be modeled in accordance with Section 9.4.1 of ASHRAE/IESNA Standard 90.1 and 7.4.3(p) and 7.4.6. No additional automatic lighting controls (e.g., programmable controls or automatic controls for daylight utilization) shall be modeled in the baseline building design, as the lighting schedules used are understood to reflect the mandatory and prescriptive control requirements in this standard.

7.

Thermal Blocks – HVAC Zones Designed

Where HVAC zones are defined on HVAC design drawings, each HVAC zone shall be modeled as a separate thermal block.

Exception: Different HVAC zones may be combined to create a single thermal block or identical thermal blocks to which multipliers are applied, provided that all of the following conditions are met:

(a) The space use classification is the same throughout the thermal block.

(b) All HVAC zones in the thermal block that are adjacent to glazed exterior walls face the same orientation or their orientations vary by less than 45 degrees.

(c) All of the zones are served by the same HVAC system or by the same kind of HVAC system.

Same as Proposed Design.

TABLE D3.1 (Continued) Modeling Requirements for Calculating Proposed and

Baseline Building Performance

No.

Proposed Building Performance

Baseline Building Performance

8.

Thermal Blocks – HVAC Zones Not Designed

Where the HVAC zones and systems have not yet been designed, thermal blocks shall be defined based on similar internal load densities, occupancy, lighting, thermal and space temperature schedules, and in combination with the following:

(a) Separate thermal blocks shall be assumed for interior and perimeter spaces. Interior spaces shall be those located greater than 4.5 m (15 ft) from an exterior wall. Perimeter spaces shall be those located within 4.5 m (15 ft) of an exterior wall.

(b) Separate thermal blocks shall be assumed for spaces adjacent to glazed exterior walls; a separate zone shall be provided for each orientation, except that orientations that differ by less than 45 degrees may be considered to be the same orientation. Each zone shall include all floor area that is 4.5 m (15 ft) or less from a glazed perimeter wall, except that floor area within 4.5 m (15 ft) of glazed perimeter walls having more than one orientation shall be divided proportionately between zones.

(c) Separate thermal blocks shall be assumed for spaces having floors that are in contact with the ground or exposed to ambient conditions from zones that do not share these features.

(d) Separate thermal blocks shall be assumed for spaces having exterior ceiling or roof assemblies from zones that do not share these features.

Same as Proposed Design.

9.

Thermal Blocks - Multifamily Residential Buildings

Residential spaces shall be modeled using at least one thermal block per living unit, except that those units facing the same orientations may be combined into one thermal block. Corner units and units with roof or floor loads shall only be combined with units sharing these features.

Same as Proposed Design.

10.

HVAC Systems

The HVAC system type and all related performance parameters in the proposed design, such as equipment capacities and efficiencies, shall be determined as follows:

(a) Where a complete HVAC system exists, the model shall reflect the actual system type using actual component capacities and efficiencies.

(b) Where an HVAC system has been designed, the HVAC model shall be consistent with design documents. Mechanical equipment efficiencies shall be adjusted from actual design conditions to the standard rating conditions specified in 7.4.3(b) and Normative Appendix C if required by the simulation model.

(c) Where no heating system exists or no heating system has been specified, the heating system classification shall be assumed to be electric, and the system characteristics shall be identical to the system modeled in the baseline building design.

(d) Where no cooling system exists or no cooling system has been specified, the cooling system shall be identical to the system modeled in the baseline building design.

The HVAC system(s) in the baseline building design shall be of the type and description specified in D3.1.1, shall comply with the general HVAC system requirements specified in D3.1.2, shall comply with any system-specific requirements in D3.1.3 that are applicable to the baseline HVAC system type(s), and shall comply with 7.3 and 7.4.3.

TABLE D3.1 (Continued) Modeling Requirements for Calculating Proposed and

Baseline Building Performance

No.

Proposed Building Performance

Baseline Building Performance

11.

Service Hot Water Systems

The service hot water system type and all related performance parameters, such as equipment capacities and efficiencies, in the proposed design shall be determined as follows:

(a) Where a complete service hot water system exists, the proposed design shall reflect the actual system type using actual component capacities and efficiencies.

(b) Where a service hot water system has been specified, the service hot water model shall be consistent with design documents.

(c) Where no service hot water

system exists or has been specified but the building will have service hot water loads, a service hot water system shall be modeled that matches the system in the baseline building design and serves the same hot water loads.

(d) For buildings that will have no service hot water loads, no service hot water system shall be modeled.

The service hot water system in the baseline building design shall use the same energy source as the corresponding system in the proposed design and shall conform with the following conditions:

(a) Where a complete service hot water system exists, the baseline building design shall reflect the actual system type using actual component capacities and efficiencies.

(b) Where a new service hot water system has been specified, the system shall be sized according to the provisions of Section 7.4.1 of ASHRAE/IESNA Standard 90.1 and the equipment shall match the minimum efficiency requirements in 7.4.4 and the heat recovery requirements in 7.4.7(b) and (c). Where the energy source is electricity, the heating method shall be electrical resistance.

(c) Where no service hot water system exists or has been specified but the building will have service hot water loads, a service water system(s) using electrical-resistance heat and matching minimum efficiency requirements of 7.4.4 and the heat recovery requirements in 7.4.7(b) and (c) shall be assumed and modeled identically in the proposed and baseline building designs.

(d) For buildings that will have no service hot water loads, no service hot water heating shall be modeled.

(e) Where a combined system has been specified to meet both space heating and service water heating loads, the baseline building system shall use separate systems complying with the minimum efficiency requirements applicable to each system individually.

(f) For large, 24-hour-per-day facilities that comply with the prescriptive criteria for use of condenser heat recovery systems described in Section 6.5.6.2 of ASHRAE/IESNA Standard 90.1, a system complying with the requirements of that section shall be included in the baseline building design regardless of the exceptions to 6.5.6.2.
Exception: If a condenser heat recovery system complying with the requirements described in Section 6.5.6.2 of ASHRAE/IESNA Standard 90.1 cannot be modeled, the requirement for including such a system in the actual building shall be met as a prescriptive requirement in accordance with 6.5.6.2, and no heat-recovery system shall be included in the proposed or baseline building designs.

(g) Service hot-water energy consumption shall be calculated explicitly based upon the volume of service hot water required and the entering makeup water and the leaving service hot-water temperatures. Entering water temperatures shall be estimated based upon the location. Leaving temperatures shall be based upon the end-use requirements.

(h) Where recirculation pumps are used to ensure prompt availability of service hot water at the end use, the energy consumption of such pumps shall be calculated explicitly.

(i) Service water loads and usage shall be the same for both the baseline building design and the proposed design and shall be documented by the calculation procedures described in Section 7.4.1 of ASHRAE/IESNA Standard 90.1.

Exceptions:

1. Service hot-water usage can be demonstrated to be reduced by documented water conservation measures that reduce the physical volume of service water required in excess of that required by 6.3.2 and 6.4.2. Examples include even more efficient low-flow shower heads. Such reduction shall be demonstrated by calculations.

2. Service hot-water energy consumption can be demonstrated to be reduced by reducing the required temperature of service mixed water, by increasing

the temperature, or by increasing the temperature of the entering makeup water. Examples include alternative sanitizing technologies for dishwashing and heat recovery to entering makeup water in excess of that required by 6.3.2, 6.4.2, and 7.4.7. Such reduction shall be demonstrated by calculations.

TABLE D3.1 (Continued) Modeling Requirements for Calculating Proposed and

Baseline Building Performance

12.

Receptacle and other Loads

Receptacle and process loads, such as those for office and other equipment, shall be estimated based on the building type or space type category and shall be assumed to be identical in the proposed and baseline building designs, except as specifically authorized by the authority having jurisdiction. These loads shall be included in simulations of the building and shall be included when calculating the baseline building performance and proposed building performance.

Other systems, such as motors covered by Section 10 of ASHRAE/IESNA Standard 90.1 and 7.4.7, and miscellaneous loads shall be modeled as identical to those in the proposed design. Where there are specific efficiency requirements in Section 10 of ASHRAE/IESNA Standard 90.1 and in 6.3.2, 6.4.2, and 7.4.7, these systems or components shall be modeled as having the lowest efficiency allowed by those requirements. Where no efficiency requirements exist, power and energy rating or capacity of the equipment shall be identical between the baseline building and the proposed design with the following exception: variations of the power requirements, schedules, or control sequences of the equipment modeled in the baseline building from those in the proposed design may be allowed by the authority having jurisdiction based upon documentation that the equipment installed in the proposed design represents a significant verifiable departure from documented conventional practice. The burden of this documentation is to demonstrate that accepted conventional practice would result in baseline building equipment different from that installed in the proposed design.

Occupancy and occupancy schedules may not be changed.

13.

Modeling Limitations to the Simulation Program

If the simulation program cannot model a component or system included in the proposed design explicitly, substitute a thermodynamically similar component model that can approximate the expected performance of the component that cannot be modeled explicitly.

Same as Proposed Design.

TABLE D3.1.1A Baseline HVAC System Types

Building Type

Fossil Fuel,

Fossil/Electric Hybrid,

And Purchased Heat

Electric and Other

Residential

System 1 – PTAC

System 2 - PTHP

Nonresidential and 3 Floors or Less and < 2,500 m2 (25,000 ft2)

System 3 – PSZ-AC

System 4 – PSZ-HP

Nonresidential & 4 or 5 Floors and <2,500 m2 (25,000 ft2) or

5 Floors or Less and 2,500 m2 to 15,000 m2 (25,000 ft2 to 150,000 ft2)

System 5 - Packaged VAV
w/ Reheat

System 6 - Packaged
VAV w/PFP Boxes

Nonresidential and More than 5 Floors or >15,000 m2 (150,000 ft2)

System 7 - VAV

w/Reheat

System 8 - VAV
w/PFP Boxes

Notes:

Residential building types include dormitory, hotel, motel, and multifamily. Residential space types include guest rooms, living quarters, private living space, and sleeping quarters. Other building and space types are considered nonresidential.

Where no heating system is to be provided or no heating energy source is specified, use the “Electric and Other” heating source
classification.

Where attributes make a building eligible for more than one baseline system type, use the predominant condition to determine the
system type for the entire building.

For laboratory spaces with a minimum of 2,500 L/s (5000 cfm) of exhaust, use system type 5 or 7 and reduce the exhaust and
makeup air volume to 50% of design values during unoccupied periods. For all-electric buildings, the heating shall be electric

resistance.

TABLE D3.1.1B Baseline System Descriptions

System No.

System Type

Fan Control

Cooling Type

Heating Type

1. PTAC

Packaged terminal air
conditioner

Constant Volume

Direct Expansion

Hot Water Fossil Fuel
Boiler

2. PTHP

Packaged terminal heat pump

Constant Volume

Direct Expansion

Electric Heat Pump

3. PSZ-AC

Packaged rooftop air

conditioner

Constant Volume

Direct Expansion

Fossil Fuel Furnace

4. PSZ-HP

Packaged rooftop heat pump

Constant Volume

Direct Expansion

Electric Heat Pump

5. Packaged VAV
w/ Reheat

Packaged rooftop variable air
volume with reheat

VAV

Direct Expansion

Hot Water Fossil Fuel
Boiler

6. Packaged VAV
w/PFP Boxes

Packaged rooftop variable air
volume with reheat

VAV

Direct Expansion

Electric Resistance

7. VAV w/Reheat

Packaged rooftop variable air

volume with reheat

VAV

Chilled Water

Hot Water Fossil Fuel
Boiler

8. VAV w/PFP
Boxes

Variable air volume with
reheat

VAV

Chilled Water

Electric Resistance

Note: Reheat shall not exceed that specified in 7.4.3(g).

D3.1.2.2 Equipment Capacities. The equipment capacities for the baseline building design shall be based on sizing runs for each orientation (per Table D3.1 No. 5a) and shall be oversized by 15% for cooling and 25% for heating; i.e., the ratio between the capacities used in the annual simulations and the capacities determined by the sizing runs shall be 1.15 for cooling and 1.25 for heating. Unmet load hours for the proposed design or baseline building designs shall not exceed 300 (of the 8,760 hours simulated), and unmet load hours for the proposed design shall not exceed the number of unmet load hours for the baseline building design by more than 50. If unmet load hours in the proposed design exceed the unmet load hours in the baseline building by more than 50, simulated capacities in the baseline building shall be decreased incrementally and the building resimulated until the unmet load hours are within 50 of the unmet load hours of the proposed design. If unmet load hours for the proposed design or baseline building design exceed 300, simulated capacities shall be increased incrementally, and the building with unmet loads resimulated until unmet load hours are reduced to 300 or less. Alternatively, unmet load hours exceeding these limits may be accepted at the discretion of the authority having jurisdiction provided that sufficient justification is given indicating that the accuracy of the simulation is not significantly compromised by these unmet loads.

D3.1.2.2.1 Sizing Runs. Weather conditions used in sizing runs to determine baseline equipment capacities may be based either on hourly historical weather files containing typical peak conditions or on design days developed using 99.6% heating design temperatures and 1% dry-bulb and 1% wet-bulb cooling design temperatures.

D3.1.2.3 Preheat Coils. If the HVAC system in the proposed design has a preheat coil and a preheat coil can be modeled in the baseline system, the baseline system shall be modeled with a preheat coil controlled in the same manner as the proposed design.

D3.1.2.4 Fan System Operation. Supply and return fans shall operate continuously whenever spaces are occupied and shall be cycled to meet heating and cooling loads during unoccupied hours. If the supply fan is modeled as cycling and fan energy is included in the energy-efficiency rating of the equipment, fan energy shall not be modeled explicitly. Supply, return, and/or exhaust fans will remain on during occupied and unoccupied hours in spaces that have health and safety mandated minimum ventilation requirements during unoccupied hours.

D3.1.2.5 Ventilation. Minimum outdoor air ventilation rates shall be the same for the proposed and baseline building designs and shall comply with 8.3.1.

Exception to D3.1.2.5: When modeling demand-control ventilation in the proposed design when its use is not required by 7.4.3(d).

D3.1.2.6 Economizers. Outdoor air economizers shall be included on all baseline HVAC systems unless the individual unit size does not exceed the capacity specified in 7.4.3(f) and Table 7.4.3-1 and the total capacity of all systems without economizers in the building project does not exceed that specified in footnote a to Table 7.4.3-1. If an economizer is not required by 7.4.3(f) and Table 7.4.3-1 including footnote a, outdoor air economizers shall not be included in baseline HVAC Systems 1 and 2. If an economizer is not required by 7.4.3(f) and Table 7.4.3-1 including footnote a, outdoor air economizers shall be included in baseline HVAC Systems 3 through 8 based on climate as specified in Table D3.1.2.6.

Exceptions to D3.1.2.6: Economizers shall not be included for systems complying with one or more of the exceptions listed below.

(a) Systems that include gas-phase air cleaning to comply with the requirements of Section 6.1.2 of ANSI/ASHRAE Standard 62. This exception shall be used only if the system in the proposed design does not match building design.

(b) Where the use of outdoor air for cooling will affect supermarket open refrigerated casework systems. This exception shall only be used if the system in the proposed design does not use an economizer. If the exception is used, an economizer shall not be included in the baseline building design.

TABLE D3.1.2.6 Climate Conditions under which Economizers are Included for

Baseline Systems 3 through 8

Climate Zone	Conditions
1A, 1B, 2A	N.R.
Others	Economizer Included

N.R. means that there is no conditioned building floor area for which economizers are included for the type of zone and climate.

D3.1.2.7 Economizer High-Limit Shutoff. The high-limit shutoff shall be a dry-bulb switch with setpoint temperatures in accordance with the values in Table D3.1.2.7.

TABLE D3.1.2.7 Economizer High-Limit Shutoff

Climate Zone	High-Limit Shutoff
1B, 2B, 3B, 3C, 4B, 4C, 5B, 5C, 6B, 7, 8	24 C (75°F)
5A, 6A, 7A	21 C (70°F)
Others	18 C (65°F)

D3.1.2.8 Design Air Flow Rates. System design supply air flow rates for the baseline building design shall be based on a supply-air-to-room-air temperature difference of 11 C (20°F). If return or relief fans are specified in the proposed design, the baseline building design shall also be modeled with fans serving the same functions and sized for the baseline system supply fan air quantity less the minimum outdoor air, or 90% of the supply fan air quantity, whichever is larger.

D3.1.2.9 Supply Fan Power. System fan electrical power for supply, return, exhaust, and relief (excluding power to fan-powered VAV boxes) shall be calculated using the following formulas:

For Systems 1 and 2,

$P_{fan} = CFM_S \cdot 0.3$

For systems 3 through 8,

$P_{fan} = bhp \times 746 / \text{Fan Motor Efficiency}$

where

P_{fan} = electric power to fan motor (watts) and

bhp = brake horsepower of baseline fan motor from Table D3.1.2.9.

Fan Motor Efficiency = the efficiency from Table C-20 for the next motor size greater than the bhp using the enclosed motor at 1800 rpm.

CFM_S = the baseline system maximum design supply fan airflow rate in cfm

TABLE D3.1.2.9 Baseline Fan Brake Horsepower

Baseline Fan Motor Brake Horsepower

Constant Volume Systems 1 – 4

Variable Volume Systems 5 – 8

$CFM_s \cdot 0.00094 + A$

$CFM_s \cdot 0.0013 + A$

Where A is calculated according to Section 6.5.3.1.1 of ASHRAE/IESNA Standard 90.1 using the pressure
drop adjustment from the proposed building design and the design flow rate of the baseline building
system. Do not include pressure drop adjustments for evaporative coolers or heat recovery devices that are
not required in the baseline building system by D3.1.2.10.

D3.1.2.10 Exhaust Air Energy Recovery. Where required by 7.4.3(k), individual fan systems shall have energy recovery with at least 60% recovery effectiveness. Sixty percent energy recovery effectiveness shall mean a change in the enthalpy of the outdoor air supply equal to 60% of the difference between the outdoor air and return air at design conditions. Provision shall be made to bypass or control the heat-recovery system to permit air economizer operation, where applicable.

Exceptions to D3.1.2.10: If any of these exceptions apply, exhaust air energy recovery shall not be included in the baseline building design.

(a) Systems serving spaces that are not cooled and that are heated to less than 16 C (60°F).

(b) Systems exhausting toxic, flammable, or corrosive fumes or paint or dust. This exception shall only be used if exhaust air energy recovery is not used in the proposed design.

(c) Heating operation for systems in climate zones 1 through 3.

(d) Cooling operation for systems in climate zones 3C, 4C, 5B, 5C, 6B, 7, and 8.

(e) Where the largest exhaust source is less than 75% of the design outdoor air flow. This exception shall only be used if exhaust air energy recovery is not used in the proposed design.

(f) Systems requiring dehumidification that employ energy recovery in series with the cooling coil. This exception shall only be used if exhaust air energy recovery and series-style energy recovery coils are not used in the proposed design.

(g) Systems serving laboratories with exhaust rates of 2,500 L/s (5000 cfm) or greater.

D3.1.3 System-Specific Baseline HVAC System Requirements. Baseline HVAC systems shall conform with provisions in this section, where applicable, to the specified baseline system types as indicated in section headings.

D3.1.3.1 Heat Pumps (Systems 2 and 4). Electric air-source heat pumps shall be modeled with electric auxiliary heat. The systems shall be controlled with multi-stage space thermostats and an outdoor air thermostat wired to energize auxiliary heat only on the last thermostat stage and when outdoor air temperature is less than 4 C (40°F).

D3.1.3.2 Type and Number of Boilers (Systems 1, 5, and 7). The boiler plant shall use the same fuel as the proposed design and shall be natural draft, except as noted under D3.1.1.1. The baseline building design boiler plant shall be modeled as having a single boiler if the baseline building design plant serves a conditioned floor area of 1,500 m2

(15,000 ft2) or less and as having two equally sized boilers for plants serving more than 1,500 m2 (15,000 ft2). Boilers shall be staged as required by the load.

D3.1.3.3 Hot Water Supply Temperature (Systems 1, 5, and 7). Hot water design supply temperature shall be modeled as 82 C (180°F) and design return temperature as 54 C (130°F).

D3.1.3.4 Hot Water Supply Temperature Reset (Systems 1, 5, and 7). Hot water supply temperature shall be reset based on outdoor dry-bulb temperature using the following schedule: 82 C at -7 C(180°F at 20°F) and below, 66 C at 10 C (150°F at 50°F) and above, and ramped linearly between 82 C and 66 C (180°F and 150°F) at temperatures between -7 C and 10 C (20°F and 50°F).

D3.1.3.5 Hot Water Pumps (Systems 1, 5, and 7). The baseline building design hot water pump power shall be 300 kW/1000 L/s (19 W/gpm). The pumping system shall be modeled as primary-only with continuous variable flow. Hot water systems serving 12,000 m2 (120,000 ft2) or more shall be modeled with variable-speed drives, and systems serving less than 12,000 m2 (120,000 ft2) shall be modeled as riding the pump curve.

D3.1.3.6 Piping Losses (Systems 1, 5, 7, and 8). Piping losses shall not be modeled in either the proposed or baseline building designs for hot water, chilled water, or steam piping.

D3.1.3.7 Type and Number of Chillers (Systems 7 and 8). Electric chillers shall be used in the baseline building design regardless of the cooling energy source, e.g., direct-fired absorption, absorption from purchased steam, or purchased chilled water. The baseline building design's chiller plant shall be modeled with chillers having the number and type as indicated in Table D3.1.3.7 as a function of building peak cooling load.

TABLE D3.1.3.7 Type and Number of Chillers

Building Peak Cooling Load

Number and Type of Chiller(s)

= 1,050 kW (300 tons)

1 water-chilled screw chiller

> 1,050 kW (300 tons),

< 2,100 kW (600 tons)

2 water-chilled screw chillers

sized equally

= 2,100 kW (600 tons)

2 centrifugal chillers minimum with chillers added so that no chiller is larger than 2,800 kW (800 tons), all sized equally

D3.1.3.8 Chilled Water Design Supply Temperature (Systems 7 and 8). Chilled water design supply temperature shall be modeled at 7 C (44°F) and return water temperature at 13 C (56°F).

D3.1.3.9 Chilled Water Supply Temperature Reset (Systems 7 and 8). Chilled water supply temperature shall be reset based on outdoor dry-bulb temperature using the following schedule: 7 C at 27 C (44°F at 80°F) and above, 12 C at 16 C (54°F at 60°F) and below, and ramped linearly between 7 C and 12 C (44°F and 54°F) at temperatures between 27 C and 16 C (80°F and 60°F).

D3.1.3.10 Chilled Water Pumps (Systems 7 and 8). The baseline building design pump power shall be 350 kW/1000 L/s (22 W/gpm). Chilled water systems with a cooling capacity of 1,050 kW (300 tons) or more shall be modeled as primary/secondary systems with variable-speed drives on the secondary pumping loop. Chilled water pumps in systems serving less than 1,050 kW (300 tons) cooling capacity shall be modeled as primary/secondary systems with secondary pump riding the pump curve.

D3.1.3.11 Heat Rejection (Systems 7 and 8). The heat rejection device shall be an axial fan cooling tower with two-speed fans. Condenser water design supply temperature shall be 29 C (85 °F) or 6 C (10 °F) approach to design wet-bulb temperature, whichever is lower, with a design temperature rise of 6 C (10 °F). The tower shall be controlled to maintain a 21 C (70 °F) leaving water temperature where weather permits, floating up to leaving water temperature at design conditions. The baseline building design condenser water pump power shall be 300 kW/1000 L/s (19 W/gpm). Each chiller shall be modeled with separate condenser water and chilled water pumps interlocked to operate with the associated chiller.

D3.1.3.12 Supply Air Temperature Reset (Systems 5 through 8). The air temperature for cooling shall be reset higher by 3 C (5 °F) temperature difference under the minimum cooling load conditions.

D3.1.3.13 VAV Minimum Flow Setpoints (Systems 5 and 7). Minimum volume setpoints for VAV reheat boxes shall be 2 L/s·m2 (0.4 cfm/ft2) of floor area served. Reheat shall not exceed that specified in 7.4.3(g).

D3.1.3.14 Fan Power (Systems 6 and 8). Fans in parallel VAV fan-powered boxes shall be sized for 50% of the peak design flow rate and shall be modeled with 0.7 W/L/s (0.35 W/cfm) fan power. Minimum volume setpoints for fan-powered boxes shall be equal to 30% of peak design flow rate or the rate required to comply with the minimum outdoor air ventilation requirement, whichever is larger. The supply air temperature setpoint shall be constant at the design condition.

D3.1.3.15 VAV Fan Part-Load Performance (Systems 5 through 8). VAV system supply fans shall have variable-speed drives, and their part-load performance characteristics shall be modeled using either Method 1 or Method 2 specified in Table D3.1.3.15.

TABLE D3.1.3.15 Part-Load Performance for VAV Fan Systems

Method 1 – Part-Load Fan Power Data

Fan Part-Load Ratio	Fraction of Full-Load Power
0.00	0.00
0.10	0.03
0.20	0.07
0.30	0.13
0.40	0.21
0.50	0.30
0.60	0.41
0.70	0.54
0.80	0.68

0.90

0.83

1.00

1.00

Method 2 – Part-Load Fan Power Equation

$$P_{fan} = 0.0013 + 0.1470 \times PLR_{fan} + 0.9506 \times (PLR_{fan})^2 - 0.0998 \times (PLR_{fan})^3$$

Where

P_{fan} = fraction of full-load fan power and

PLR_{fan} = fan part-load ratio (current cfm/design cfm).

TABLE D3.2 Power Adjustment Percentages for Automatic Lighting Controls

Automatic Control Devices(s)

Non-24-hr and

= 500 m^2 (5,000ft^2)

All Other

(1) Programmable timing control

10%

0%

(2) Occupancy sensor (where not required by 7.4.6(b) or (c))

15%

10%

(3) Occupancy sensor and programmable timing control (where not required by 7.4.6(b) or (c))

15%

10%

Note: The 500 m2 (5,000 ft2) condition pertains to the total conditioned floor area of the building.

(This is a normative appendix and is part of this standard.)

NORMATIVE APPENDIX E

SPACE CONTAMINANT CONCENTRATION ACTION LEVELS

This Appendix defines the space CO2 concentration to use as the action level for outdoor air monitoring described in section 10.3.3.4. Values are based on the ASHRAE Standard 62.1 Table 6-1 Minimum Ventilation Rates in Breathing Zones, using the resulting Combined Outdoor Air Rates per Person, default occupant densities and two metabolic activity levels. Metabolic activity levels are stationary (MET=1.0) and more active (MET=1.5).

To use Table E-1, first determine the per person outdoor ventilation air required in 8.3.1 of this Standard. The CO2 concentration action level for each space requiring CO2 monitoring shall be taken from the column labeled MET=1.0, unless the occupants are expected to be active (for example, in public assembly lobbies) where the MET=1.5 column is allowed.

TABLE E-1 Space Carbon Dioxide Concentration Action Levels
(Differential of Breathing Zone Space Above Ambient)

Combined Outdoor Air Rateper Person

Action Level
Concentration (ppm)

l/s

Cfm

MET=1.0

MET=1.5

2.3 to 2.7

5

1,800

2,600

2.8 to 3.3

6

1,500

2,200

3.4 to 3.7

7

1,300

1,900

3.8 to 4.3

8

1,200

1,700

4.4 to 4.7

9

1,100

1,500

4.8 to 5.1

10

1,000

1,400

5.2 to 5.5

11

900

1,300

5.6 to 6.0

12

800

1,200

6.1 to 6.7

13

800

1,100

6.8 to 7.0

14

700

1,000

7.1 to 7.4

15

700

1,000

7.5 to 7.7

16

700

900

7.8 to 7.9

17

600

900

8.0 to 8.3

18

600

800

8.4 to 9.0

19

600

800

9.1 to 10.0

20

600

800

10.1 to 10.6

21

500

700

10.7 to 11.0

22

500

700

11.1 to 11.5

23

500

700

11.5 to 11.9

24

500

700

12.0 to 12.4

25

500

600

12.5 to 13.0

26 or more

500

(This appendix is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

INFORMATIVE APPENDIX F

INFORMATIVE REFERENCES

This appendix contains informative references for the convenience of users of this standard and to acknowledge source documents when appropriate.

Reference

Title

Section

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
1791 Tullie Circle NE
Atlanta, GA 30329
United States
1-404-636-8400; www.ashrae.org

The Commissioning Process

10.3.1.1

ASHRAE Guideline 1-2007

HVAC&R Technical Requirements to Support the
Commissioning Process

10.3.1.1

ASHRAE Guideline 4-1994

Preparation of Operating and Maintenance
Documentation for Building Systems

10.3.1.1

ASHRAE Handbook

Fundamentals – 2005

Appendix
D

ASHRAE Handbook

HVAC Applications – 2007

Appendix
G

California Energy Commission (CEC)

1519 Ninth Street

Sacramento, CA 95814
United States

1-800-772-3300 and 916-654-4287; www.energy.ca.gov

CEC-400-2005-006-CMF (April 2005)

Nonresidential Compliance Manual for California's
2005 Energy Efficiency Standards

10.3.2.1

Canadian Standards Association (CSA)

5060 Spectrum Way, Suite 100
Mississauga, Ontario, L4W 5N6

Canada

1-800-463-6727 and 1-416-747-4000; www.csa.ca

9.4.1.3

CSA S478-95 (R2001)

Guideline on Durability for Buildings

Appendix
K

Carpet and Rug Institute

730 College Drive

Dalton, Georgia 30720

United States

1-706-278-3176; www.carpet-rug.org

9.4.2.3

Forest Stewardship Council (FSC)

1155 30th Street NW, Suite 300
Washington, DC 20007
United States

1-202-342-0413; www.fsc.org

9.4.1.3

Institute of Transportation Engineers

1099 14th Street NW, Suite 300 West

Washington, DC 20005-3438

United States
1-202-289-0222; www.ite.org

3rd Edition, 2004

Parking Generation

10.3.6

Market Transformation to Sustainability (MTS)

1511 Wisconsin Avenue, N.W.

Washington, D.C. 20007
United States

1-202-338-3131; www.sustainableproducts.com

MTS 1.0 WSIP Guide – 2007

Whole Systems Integrated Process Guide for
Sustainable Buildings and Communities

Appendix
G

National Institute of Building Sciences

1090 Vermont Avenue, NW, Suite 700

Washington, DC 20005-4905

(202) 289-7800; www.nibs.org

NIBS Guideline 3-2005

Exterior Enclosure Technical Requirements for the
Commissioning Process

10.3.1.1

Programme for the Endorsement of Forest Certification schemes (PEFC)

2éme Etage
17 Rue des Girondins
Merl-Hollerich
L - 1626 Luxembourg

352-26-25-90-59; www.pefc.org

9.4.1.3

Resilient Floor Covering Institute

401 East Jefferson Street, Suite 102

Rockville, Maryland 20850

United States

1-301-340-8580; www.rfci.com

9.4.2.3

Sheet Metal and Air Conditioning Contractors National Association (SMACNA)

4201 Lafayette Center Drive

Chantilly, VA 20151
Unites States

1-703-803-2980; www.smacna.org

SMACNA – 1995

IAQ Guidelines for Occupied Buildings under Construction

10.3.8

Sustainable Forestry Initiative, Inc. (SFI)

1600 Wilson Blvd, Suite 810

Arlington, VA 22209
United States

1-703 875 9500; www.sfiprogram.org

9.4.1.3

United States Department of Energy (USDOE)

Washington, DC 20585

United States

1-202-586-5000; www.energyplus.gov

EnergyPlus (or predecessors BLAST or DOE-2)

Appendix
D

United States Environmental Protection Agency (USEPA)

1200 Pennsylvania Ave NW

Washington, DC 20460

United States

1-888-782-7937 and 1- 202-775-6650; www.energystar.gov

USEPA #430-R-07-002

Inventory of U.S. Greenhouse Gas Emissions and
Sinks: 1990-2005 (April 2007)

9.5.1.2

Portfolio Manager

10.3.3.3.1

United States General Services Administration (USGSA)

1800 F Street, NW
Washington, DC 20405

1-800-488-3111 and 1-202-501-1100; www.gsa.gov

U.S. GSA – 2005

The Building Commissioning Guide

10.3.1

(This appendix is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the
ANSI requirements for a standard and may contain material that has not been subject to public
review or a consensus process. Unresolved objectors on informative material are not offered the right
to appeal at ASHRAE or ANSI.)

INFORMATIVE APPENDIX G

INTEGRATED DESIGN

G1 Integrated Design Process/Integrated Project Delivery. An integrated design process, also known as integrated project delivery, requires early stakeholder collaboration to enable stronger, more balanced design solutions in all aspects of a project through the sharing of knowledge and expertise among project team members. This integrated design process is in contrast to the traditional method, where there is a limited utilization of the skills and knowledge of all stakeholders in the development of design solutions. An integrated design process enables the construction of high-performance green buildings that consume fewer resources and achieve better comfort and functionality.

The integrated design process facilitates higher building performance by bringing major issues and participants into the project early in the design process. For the most part, the opportunities for creatively addressing solutions occur very early in the design process. Early team building and goal setting can reduce total project costs. This collaborative process will inform building form, envelope, and mechanical, electrical, plumbing and other systems. The later in the design process, the more expensive the implementation.

An iterative design process is necessary to take full advantage of the collective knowledge and skills of the design team. A linear process approaches each problem sequentially. In contrast, an integrated design process approaches each problem from the different viewpoints of the participants and the issues they represent, circling back after each design decision to evaluate the impact on all stakeholders. This process acknowledges the complex interdependency of all building systems and their relationship to resource consumption and occupant well being.

There are several existing, and currently evolving, models for collaboration which can be considered: for example, the ASHRAE Handbook HVAC Applications, 2007, Chapter 57; and the MTS 1.0 WSIP Guide - 2007, Whole Systems Integrated Process Guide for Sustainable Buildings and Communities.

The integrated design process must include a design charrette. The following outlines one type of design charrette process that has resulted in successful integrated design.

G1.1 Design Charrette. At the initial stages of building design, a charrette process can be initiated and the members of the process should include all the stakeholders. The charrette process should be held for a minimum of three (3) days and a maximum of seven (7) days.

Exception to G1.1: Building projects containing less than 10,000 gross square meters (100,000 gross square feet) can have a charrette design process of less than three days.

G1.2 Charrette Process. Experienced personnel with a minimum of 10 years of experience in their specialty should participate in the charrette process. A discussion of all the systems and all the items that affect the integrated design should be discussed. Stakeholders should be able to decide and vote on the best integrated system.

The integrative team process should entail the following steps of design optimization:

(a) The original goals and budget of the project should be revisited to see whether the overall intentions of the project are intact.

(b) The project should be compared against this standard or at least one existing Green rating system.

(c) Each of the building and site components should be scrutinized to help ensure natural systems for energy conservation, lighting, ventilation and passive heating and cooling are maximized before mechanical systems are engaged.

(d) The appropriateness and integration logic of the building's primary systems should be confirmed.

(e) The impact of the design on the site and its larger context should be evaluated, including the environmental impact on a life cycle cost basis.

(f) Building information modeling (BIM) software, design tools and the experience of the design team should be used if practical to help optimize the design.

(g) All members of the design team should be included when making design decisions.

(h) Commissioning and consideration of future operation and maintenance (O&M) requirements should be included within the design optimization process.

G1.3 Design Charrette Matrix. At the end of the charrette process, a matrix (Figure

G1) for each proposed building scheme can be developed and evaluated to summarize the impact on the site, water, energy, materials, and indoor environmental quality and to help lead to a decision as to the best integrated system. The matrix contains cells indicating the high-performance value, grading a particular building system to its appropriate high-performance criteria. Each high-performance value is qualitatively rated from 1 to 10, with 1 being the lowest (minimal energy savings, low air quality, low water efficiency, high cost); and 10 being the highest (high energy savings, high air quality, high water efficiency, low cost). The average of the high-performance values for each building system is the aggregate index. Selection of the best system should be based upon a comparison of these aggregate indices for each matrix.

Figure G1.2 Sample Charrette Design Matrices

Scheme #1 – with Atrium, maximum exposure on the south, three-story office building.

Building System

High Performance Criteria

Site

IAQ

IEQ

Energy

Comm.

Initial
Cost

O & M

M&V

Arch

8

7

6

1

6

1

6

HVAC

-

5

6

2

6

2

7

Plumbing

N/A

-

-

-

-

2

7

Structural

-

-

-

-

2

Aggregate index

8

6

6

1.5

6

2

6.8

Result:

Least numbers under energy and cost column defines consumption of substantial energy with high initial cost.

Scheme #2 – without Atrium, three-story, minimum exposure on the south and west side

Building System

High Performance Criteria

Site

IAQ

IEQ

Energy

Comm.

Initial
Cost

O & M

M&V

Arch

6

7

7

7

7

7

6

HVAC

N/A

5

7

7

7

7

7

Plumbing

N/A

-

-

-

7

7

7

Structural

-

-

-

-

-

Aggregate index

6

6

7

7

7

7

6.8

Result:

High numbers on all columns indicate the building is conceived optimally.